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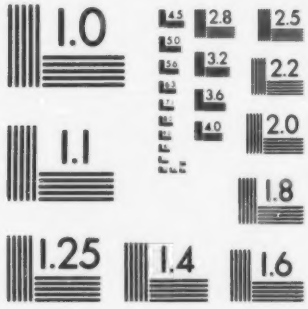

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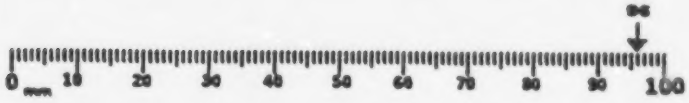

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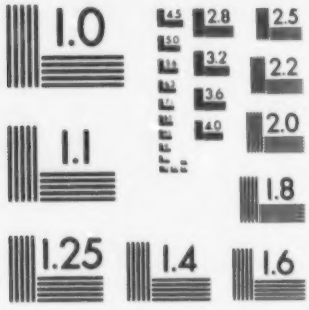

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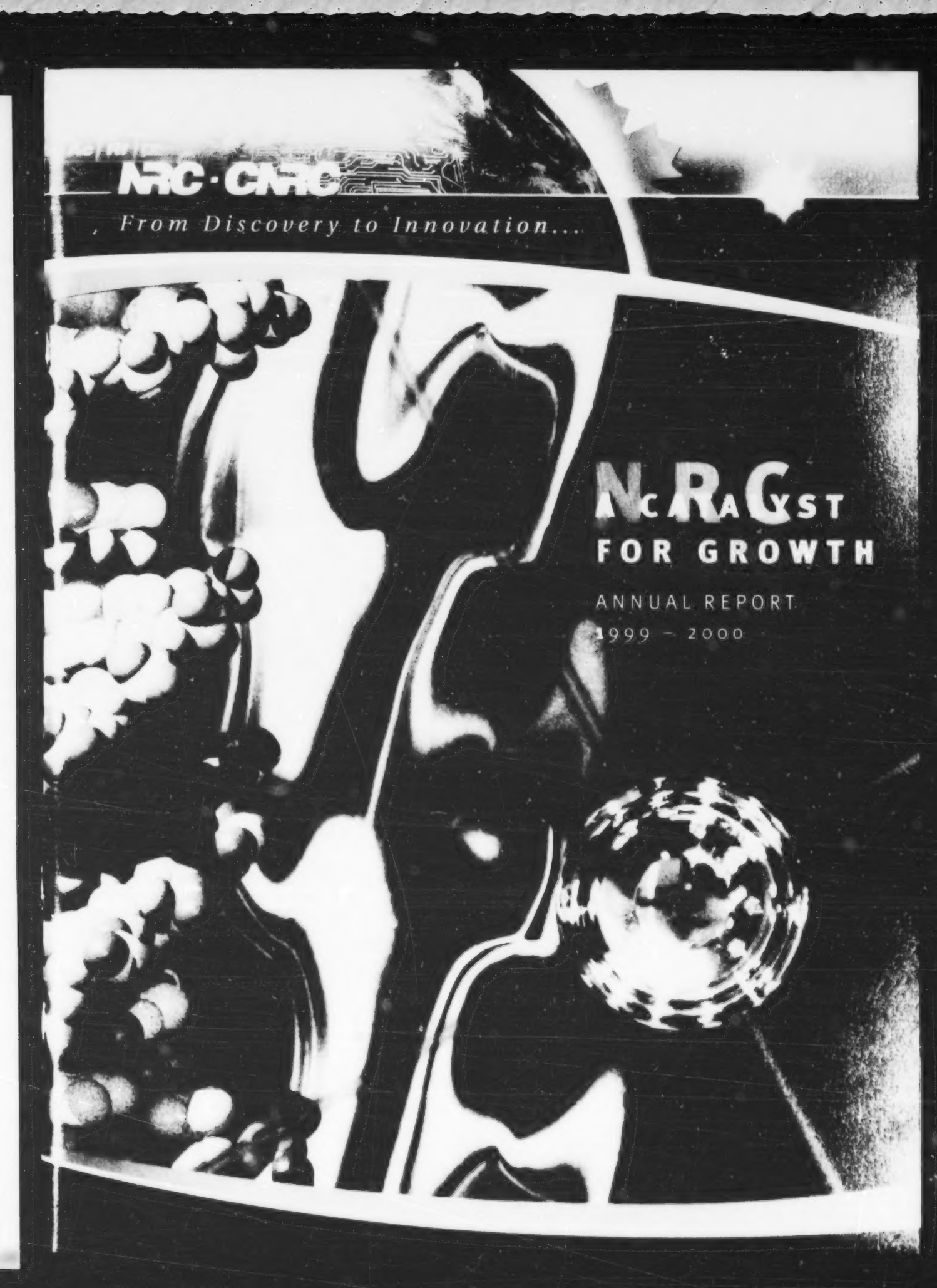
NRC·CNRC
From Discovery to Innovation...
NRC RAGYST
FOR GROWTH
ANNUAL REPORT
1999 – 2000

NATIONAL RESEARCH COUNCIL OF CANADA

NRC is a knowledge and innovation organization. Its primary business is scientific and technological research and development.

Since its founding in 1916, NRC's goal has been to undertake, assist and promote scientific and industrial research in the national interest. Working with other organizations, it provides an essential bridge linking strategic research to Canada's economic growth and productivity.

NRC conducts research in three strategic technology areas: biotechnology, manufacturing, and information and communications technology. In addition, it carries out research in aerospace, construction, ocean engineering, national measurement standards, surface transportation, and coastal and environmental hydraulics. Through the Herzberg Institute of Astrophysics, NRC provides access to national and international astronomical facilities and carries out leading-edge research in astrophysics. NRC is also responsible for other major science facilities including TRIUMF (Canada's national laboratory for particle physics) and the Neutron Program for Materials Research (NPMR). NRC continues to explore new frontiers in the molecular sciences, which will pave the way to the next generation of technological developments.

With a workforce of 3000, NRC offers Canadian industry and the Canadian scientific community a wide range of R&D support services. This support includes: collaborative research programs; access to the organization's national facilities and installations; technical advice and expertise; hands-on training of high-quality personnel; licensing opportunities; testing, analysis, verification and calibration services; creating new incubator facilities and providing access to leading-edge research information through the Canada Institute for Scientific and Technical Information (CISTI), Canada's largest resource for scientific, technical and medical information.

In laboratories and facilities from coast to coast, NRC's specialized staff work in key technology areas, supporting those Canadian industries with the potential to make an impact on Canada's productivity and competitiveness.

More recently, NRC has placed increased emphasis on fostering innovation in the Canadian economy, transforming its know-how and technology into products and services for the marketplace. The organization works across a broad spectrum to help build an innovative, knowledge-based economy performance by linking together the infrastructure, systems and key players through targeted strategies at the national, regional and local levels.

And through its Industrial Research Assistance Program (IRAP), NRC transfers knowledge, advice and technology to the small and medium-size enterprise (SME) community and delivers the services of the Canadian Technology Network.

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VISION

As Canada's foremost R&D Agency, NRC will be a leader in the development of an innovative, knowledge-based economy through science and technology.

We will realize this vision by:

- *Being dedicated to excellence in advancing the frontiers of scientific and technological knowledge in areas relevant to Canada*
- *Carrying out research, in collaboration with industrial, university and government partners to develop and exploit key technologies*
- *Providing strategic analysis and national leadership to integrate key players in Canada's system of innovation*
- *Taking a more aggressive, entrepreneurial approach to ensure the transfer of our knowledge and technological achievements to Canadian-based firms*

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THE PRESIDENT'S MESSAGE: FROM VISION TO REALITY

When NRC launched its Vision four years ago, we charted a new course to the future, one that would integrate our traditions and strengths in R&D with new opportunities to build Canada's innovation capacity. Today's NRC is dramatically different from what it was just four years ago.

We have undergone a fundamental transformation to a knowledge and innovation organization – one that not only generates new knowledge and technology through leading-edge research, but creates new enterprises to commercialize the results of that work and fosters the growth of technology clusters across Canada through local and community innovation.

At Work Across the Spectrum
In 1999-2000, our successes at all stages of the innovation spectrum – from fundamental research discoveries, to new product and services development, and on to the creation of spin-off firms – are there for everyone to see:

- New strategic innovation initiatives aimed at developing globally competitive technology clusters in regions and communities across Canada, focussing on key industry sectors
- Enhanced research capacity with new facilities, new collaborations and new initiatives in genomics, aerospace, environmental technologies, biotechnology, and other fields
- New incubator facilities and spin-off companies to commercialize technologies from our own Institutes, and co-development and transfer of new technologies, leading to countless new products and services for export
- Advice and/or financial assistance, through IRAP and CTN, to more than 12,000 clients, reducing the risk that small and medium-size companies face in trying to bring new technologies to the point where these can be commercialized
- Continuing initiatives to attract, train and retain the high talent people Canada needs – through our guest worker program, post doctoral fellowships, and work experiences and training for the best and brightest young science and engineering students who are the future of science and technology in Canada.

Building Canada's Innovation Capacity
This Annual Report highlights several of our achievements in 1999-2000...in developing new scientific knowledge...in R&D breakthroughs and the commercialization of new technologies... in building Canada's innovation capacity.

In the end, however, it is a report about the creativity, ingenuity and dedication of people – the NRC researchers, scientists, technologists and program support staff who first forged our vision, and then set to work to bring it to life. It is these people who are responsible for NRC's research excellence and who deliver NRC's innovation agenda, helping build Canada's tomorrows today.

As we enter the 21st century, NRC is an organization that has moved from vision to reality, serving as a catalyst to bring together all the participants in the "discovery to innovation" spectrum to help drive our economic growth – for the benefit of all Canadians.

Arthur J. Carty

NRC – A CATALYST FOR GROWTH

In the knowledge-based economy of the 21st century, the advantage goes to those countries that innovate, have high levels of productivity, quickly adopt the latest technologies, invest in skills for their citizens, and seek out new opportunities around the world.

Speech from the Throne
October 12, 1999

"Our strategy is to connect our core research strengths and our knowledge and partnership networks with the commercial development and product-oriented activities of industry to produce a winning innovation formula. Together, we make the best use of research, professional, technical, financial and other resources to promote innovation and create globally competitive clusters of innovation and technology growth. This is the key to our role as a catalyst for Canada's economic growth."

Arthur J. Carty
President
National Research Council

"Constant change" is the defining concept for the 21st century.

Throughout its history as Canada's national science and technology agency, NRC has pursued one overriding objective: to lead and sustain scientific research for the generation of knowledge and the support of industry in the best interest of Canada and Canadians. In the eight decades since its founding, NRC has focused on the future, anticipating change and the opportunities and challenges it brings, to meet the country's emerging needs.

In the mid-1990s, NRC recognized that innovation and knowledge would be the critical success factors for Canada's economy. While Canada has always had world-class capacity to create new knowledge and ideas, it has lagged behind other nations in moving these ideas into the marketplace. Improving Canada's capacity to innovate – to transfer discoveries and inventions swiftly and efficiently from the laboratory to the world's markets – is fundamental to our productivity and future economic growth. Ultimately, our success as a nation in fuelling innovation will determine how well we fare in the global knowledge economy of this new century.

Using its Vision as the blueprint, NRC is working to tap the full potential of new knowledge and technologies to help build Canada's innovation system, foster greater productivity, and generate new wealth.

NRC's unique contribution to Canadians is its ability to serve as a key catalyst for all the fundamental elements necessary to foster new ideas:

- Undertaking cutting-edge R&D in key fields to advance knowledge and support industry in the interests of all Canadians
- Increasing Canada's S&T innovation capacity – in strategic industry sectors, communities and regions across Canada
- Building essential national research and development infrastructure
- Linking the key players from all sectors – business, academic, and government – and working in partnership to form the critical mass of resources needed to create world-class, globally-competitive centres of innovation and growth
- Creating and applying S&T knowledge – the new currency of the new economy.

By serving as a catalyst to help transform new discoveries into new products and services, NRC helps build Canadian firms, creates jobs, fuels economic growth through improved competitiveness and contributes to a higher quality of life for all Canadians.

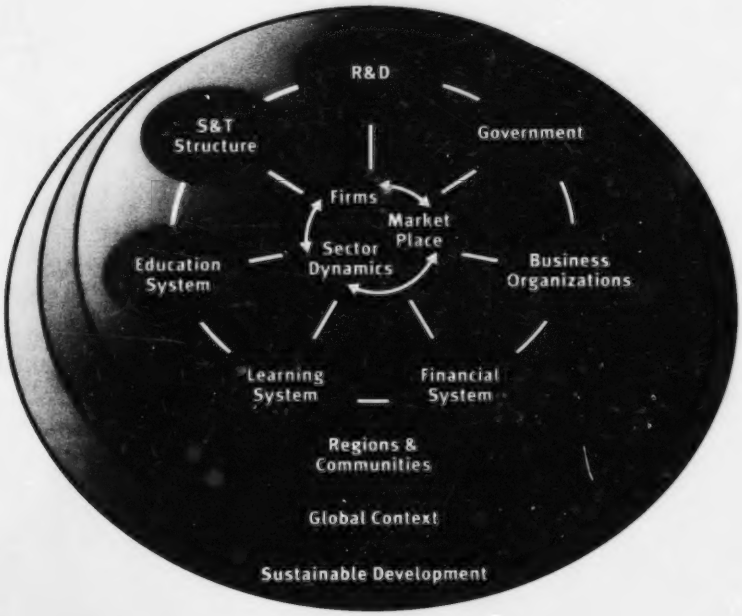
BUILDING CANADA'S INNOVATION CAPACITY

NRC is the Government of Canada's most powerful instrument for supporting advances in science and technology innovation in every region of Canada. It makes key contributions by working in partnership with industry, governments, and universities across the "discovery to innovation" spectrum.

Strategic, long-term R&D investments
NRC works in fields of strategic national and economic importance, making long-term, sustained investments in R&D most relevant to Canada's current economy and the future needs of Canadians.

Unique national facilities
NRC is the home of unique national facilities for scientific and engineering research, the nation's largest agency for the collection and distribution of scientific, technical and medical information, and Canada's agency for science-based measures and standards.

SYSTEM OF INNOVATION



NRC: CORE STRENGTHS FOR CANADIAN INNOVATION

- **16 Research Institutes**
- **4 Innovation and Technology Centres**
- **3,000 highly skilled staff**
- **1,000 guest workers**
- **sustained research in critical sectors: biotechnology, manufacturing technology, information and communications technology, aerospace, construction, ocean engineering, molecular sciences, astronomy and astrophysics**
- **national knowledge and information resources and systems**
- **technology advisory, financial and other support services and networks for industry**
- **technology development, diffusion and commercialization infrastructure**
- **incubator facilities, start-up support and spin-offs in new economy industries**
- **local, regional, national and international networks – access for Canadian R&D to the world**
- **standards, codes and measures – enhancing access to markets**
- **training and experience programs and networks**
- **local, regional, national innovation and technology clustering initiatives and networks**

National scope – community presence
In addition to their national mandates, NRC Institutes, Innovation and Technology Centres. the Industrial Research Assistance Program (IRAP), the Canada Institute for Scientific and Technical Information (CISTI) and the Canadian Technology Network (CTN) provide a highly visible and valued federal government S&T presence and access point for industry and universities in regions and communities across Canada.

Links in the chain
NRC forges partnerships, collaborations and other linkages with universities, governments and businesses, at home and internationally. It is these relationships that are the key to bringing together the components of our national innovation system to drive the economic growth Canada needs.

World-class workforce
With a world-class workforce of scientists, engineers and technical staff, and more than 1,000 guest workers, NRC conducts leading-edge R&D in areas relevant to Canada's economy. Our efforts in discovery today will help create the products and services of tomorrow.

Networking for success
NRC houses Canada's best S&T knowledge, information and technology transfer systems, and infrastructure. Its networks include CISTI, IRAP, CTN, ties with other federal science-based agencies and regional development organizations, as well as extensive national and international connections.

Leadership in building technology clusters
NRC provides leadership and management expertise in successfully developing regional and community-based innovation and technolc gy clusters in centres across Canada.

National research capacity

NRC makes strategic long-term investments in a broad range of R&D, facilities, support programs, and activities most relevant to Canada's knowledge-based economy. It puts the strengths of this R&D infrastructure to work in each region of the country.

The research institutes, with their top-flight facilities and staff, are the core of our innovation effort. Their connection with other NRC strengths – like our national S&T information infrastructure (CISTI) and our extensive partnerships with industry, university, and government sectors (including IRAP and CTN) – forms the backbone of the national innovation infrastructure.

NRC's new DNA sequencing facility at the Institute for Marine Biosciences (IMB) in Halifax, Nova Scotia will support the development of biotechnology applications leading to improvements in human health, food crops, and the environment.

The Canadian Centre for Housing Technology (CCHT) – Canada's innovative new research, testing and demonstration facility for advanced housing construction technology.

The Anechoic Chamber at the Institute for Microstructural Sciences (IMS) – a world-renowned acoustic testing facility for NRC researchers and industrial clientele.

Work underway at the Biotechnology Research Institute (BRI)'s Procrea genomics lab in Montreal – part of NRC's biotechnology clustering initiatives.

NRC –
KEY NATIONAL FACILITIES:
FUNDAMENTAL INFRASTRUCTURE FOR INDUSTRY

- **Industry Partnership and incubator facilities**
- **Large scale protein purification facility**
- **Ultra-fast laser laboratory**
- **Nuclear Magnetic Resonance facilities**
- **Mass spectrometry facilities**
- **Aquaculture Research Station**
- **Plant DNA Sequencing Facility**
- **Virtual Antenna Lab**
- **Aerodynamics Lab**
- **Wind Tunnels**
- **Flight Research Laboratory & aircraft**
- **Gas Turbine Engine Test Cells**
- **Full-scale aircraft structural test facilities**
- **Marine Dynamics Test Facility**
- **Epitaxy growth systems**
- **Astronomical observatories & data systems**
- **Canadian Bioinformatics Resource**
- **Canadian Centre for Housing Technology**
- **Virtual Environment Technology Centre**
- **National metrology facilities**

...and many more.

"IMTI invited us to take part in a partnership and it is one of the best decisions [General Motors Defence] has ever made... The facilities that you visit today and the expertise of the people who are here to help you cannot be matched anywhere. For small and medium-sized companies, even like ours, these are facilities and levels of expertise that we can't afford to have in our own business."

Mr. Keith Zerebecki
Deputy Director
General Motors Defence

In 1999-2000, NRC made significant progress in building on Canada's core infrastructure and innovation capacity across Canada.

New facility tests surface and underwater vehicles
NRC and the Department of National Defence commissioned the jointly-funded Marine Dynamic Test Facility in St. John's, Newfoundland. The facility provides government, universities and industry with a capacity for unique experiments related to the performance of surface and underwater vehicles – of major importance to Canada's shipping, defence, and offshore oil and gas industries.

New Housing Technology Centre a hit
In Ottawa, NRC, Natural Resources Canada and Canada Mortgage and Housing Corporation completed the Canadian Centre for Housing Technology (CCHT) as a shared research, testing and demonstration facility for advanced Canadian housing construction technology. The first joint research project involving two firms and NRC is under way, with several more in negotiation. The Centre attracted over 800 visitors during 1999-2000, including international delegations from Chile, China, Russia, Japan and the United Kingdom.

Biotechnology cluster – strength through integration
NRC's Biotechnology Group, comprising five biotechnology Institutes, expanded its genome sciences program in agriculture, pathogenesis, age-related diseases and health diagnostics. In collaboration with government, universities and industry partners, their work focuses on establishing leading-edge R&D capabilities that create a Canada-wide genomics research network, supported by infrastructure that provides high capacity DNA sequencing, bioinformatics, proteomics and DNA microarray technology. These R&D activities will help foster the growth of regional innovation and biotechnology clusters around each institute.

Leading the way in DNA sequencing
In Halifax, Nova Scotia, NRC established one of Canada's largest, most advanced DNA sequencing facilities at the Institute for Marine Biosciences (IMB). This facility will be used to sequence microbial genomes from a variety of human and animal pathogens and parasites, including those of aquatic species.

Virtual reality: saving time and money for industry
In London, Ontario, the Minister of Industry, the Honourable John Manley, officially opened the Virtual Environment Technologies Centre of NRC's Integrated Manufacturing Technologies Institute (IMTI). This new Centre will give Canadian manufacturers a competitive advantage by providing them with facilities to bring the design of new products and processes to the ready-for-market stage without prototypes. They will be able to run simulations of designs and production processes more efficiently and quickly, without having to make a single hard manufacturing commitment.

Building community-based innovation

The development of regional and community-based technology clusters is vital to nurturing innovation and sustaining economic growth as well as creating new wealth in Canada. NRC has successfully supported the development of globally competitive innovation clusters by working with universities, private business, financial institutions and other government organizations at federal, provincial and municipal levels.

NRC's approach is to link local strengths and opportunities in industry sectors to its core R&D capacities. Community consultations help determine the best path to capitalize on these strengths and to tap into unique local sources of competitive advantage.

In 1999-2000, NRC made significant progress in a number of communities across Canada to develop focused regional innovation clusters in new locations.

Ottawa – regional centre spurs local and national innovation
The creation of the Regional Innovation Office in Ottawa in 1995 and its subsequent upgrading to a Regional Innovation Centre in 1999 has had significant impact in the local community and has supported NRC's national innovation efforts. Some of the key activities and achievements of this Centre since its founding include:

- Creation of the Regional Innovation Forum bringing together industry, government and universities, and the hosting of five roundtables on issues related to community needs that have led to key actions
- Spin-off of seven companies that have helped to generate over 140 new jobs in the region and sales well in excess of $15 million over the past five years
- Raising of $27 million in investment capital for commercialization of new technologies
- Working with Revenue Canada to improve the administration of the Scientific Research & Education tax credits
- Studies to assist the Department of Finance with legislation to encourage re-investments in technology-based start-ups
- Introduction of Regional Innovation Awards to advance S&T in the region.

Telecom research attracts the best
Inaugurated in 1999, the National Capital Institute of Telecommunications (NCIT) is a collaborative undertaking of NRC's Information and Communications Technology Group, the University of Ottawa, Carleton University, the Communications Research Centre and industry, with financial support from the Canada Foundation for Innovation and the Ontario Research and Development Challenge Fund. NCIT is creating a region-wide centre to attract and retain the best high tech students and researchers by conducting pre-competitive research in telecommunications, broadband networks and applications.

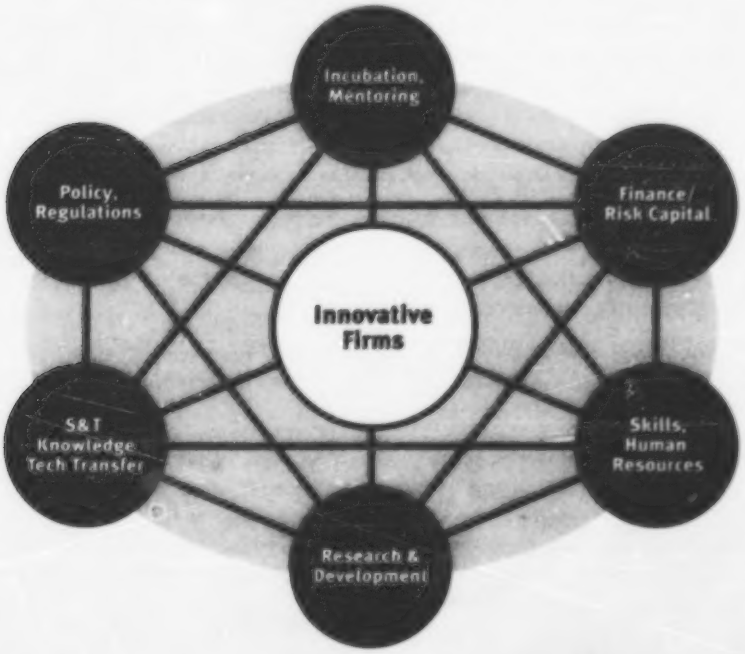
SO JUST WHAT IS A TECHNOLOGY CLUSTER?

From Silicon Valley in California to Saskatoon's agbiotech-focused Innovation Research Park, the trend in the global economy is on harnessing local strengths to create globally competitive clusters of expertise and technology.

"Clusters are geographic concentrations of interconnected companies and institutions in a particular field. Clusters encompass an array of linked industries and other entities important to competition. Many clusters include governmental and other institutions – such as universities, standards setting agencies, think tanks, vocational training providers and trade associations – that provide specialized training, education, information, research, and technical support."

Michael Porter
Harvard Business Review

TECHNOLOGY CLUSTERS – A NEW APPROACH



The Canadian Light Source (CLS) is under construction on the campus of the University of Saskatchewan, thanks in part to a $4 million financial contribution by NRC. CLS will be Canada's first synchrotron, a facility that uses light beams 10,000 times brighter than the sun to study atomic-size matter with greater precision than ever before. Researchers will use it to study the structures of proteins, to develop new drugs, to analyse minerals, and to design semiconductor materials.

"Saskatchewan's international reputation as a strong and vigorous knowledge-based technology cluster will continue to expand because of this powerful research tool [the Canadian Light Source]. In addition to its profound impact upon Canada's research community, synchrotron technology will also be of vital importance in building Canada's innovative capacity. The facility will allow Canadian research and development to remain competitive with the rest of the world."

Dr. Peter Hackett
Vice President, Research
National Research Council

Nurturing a life sciences cluster
Life sciences has been identified as one of seven key economic development sectors for the national capital region. NRC is contributing to the development of a life sciences cluster by encouraging spin-offs and start-up companies in this sector. NRC collaborated with the Ottawa Life Sciences Council (OLSC) to establish an expanded Biotechnology Incubation Centre in Ottawa and participated in the development of the Canadian Bio-Products Research Institute. In addition, support has been provided for OLSC's annual National Biotechnology Conference and the Health Sector Workshops of the Economic Generators Initiative hosted by the Technology Opportunities Partnership.

Montréal – remediation reclaims urban sites
The Montréal Centre of Excellence in Brownfields Remediation (MCEBR) went into full operation, with six industrial collaborations signed, four more in negotiation, and the launch of the full technology platform on schedule for the Fall of 2000. Initiated by NRC's Biotechnology Research Institute (BRI) in collaboration with Canada Economic Development (CED), Environment Canada and the City of Montréal, the MCEBR is helping solve the problems of contaminated urban sites, or brownfields, by developing effective bioremediation methods. In addition to the reclamation benefits, this initiative serves as an anchor for the development of a biotechnology cluster in the Montréal region, where there are some 200 brownfield sites. With over 2,500 such sites across Canada, this initiative has the potential for national impact in the years ahead.

Saskatchewan – from blueprint to action
In 1999-2000, NRC continued to implement the Saskatchewan Blueprint for Innovation, first released in 1998. The Blueprint received additional support from IRAP and the Canadian Technology Network through technology visits, networking and the establishment of new partnerships.

The Canadian Light Source (CLS) is under construction on the campus of the University of Saskatchewan, thanks in part to a $4 million financial contribution by NRC. CLS will be Canada's first synchrotron, a facility that uses light beams 10,000 times brighter than the sun to study atomic-size matter with greater precision than ever before. The synchrotron will be used to carry out fundamental scientific research across a broad spectrum of disciplines, from the physical sciences and materials engineering to the biosciences and medicine. It will be applied to study the structures of proteins, to develop new drugs, to analyze minerals, and to design semi-conductor materials.

Plans were also finalized to expand the Plant Biotechnology Institute's research and incubation capacity. Construction of a new Industry Partnership Wing, to house incubator facilities and increase collaborative research with biotech companies, is slated to begin in 2000-2001.

Vancouver – consolidating presence and impact
In 1999, the activities of the NRC Innovation Centre in Vancouver, British Columbia were refocused on creating a National Fuel Cells Research and Innovation Initiative, a co-operative venture between NRC, the Natural Sciences and Engineering Research Council (NSERC) and Natural Resources Canada. The Centre has three principal functions: to serve as the focal point for NRC's national fuel cell R&D activities; to foster linkages between NRC programs and the research and industrial communities in British Columbia; and to support networking and partnerships in the region to help remove barriers to innovation.

Winnipeg – medical technologies advancement
NRC has contributed significantly to the federal government's $100 million Western Medical Technologies Strategy, first announced in 1997. This strategy targets investments for the commercialization of technologies developed for medical research. Among the 1999–2000 highlights:

- Five medical technology-based spin-off companies from the Institute for Biodiagnostics: IMRIS, NeuroMRIS, MRV Systems, nir-vivo and NovaDAQ Technologies
- Two new MRI systems for clinical and research purposes located in Winnipeg's major teaching and research hospitals
- The only intraoperative MRI system of its type in the world, located in Calgary's Foothills Hospital
- A veterinary MRI demonstration site in the Western College of Veterinary Medicine at the University of Saskatchewan
- A demonstration site at Vancouver General Hospital for low-field, permanent magnet MRI.

In addition, the strategy is now having national impact with the development of a network of MRI demonstration sites across Canada. An instrument was installed in St. Joseph's Hospital in London, Ontario in 1999, with plans underway to set up the same competencies in Halifax, Nova Scotia.

Atlantic Canada – regional innovation strategies for the future
In 1999-2000, NRC developed regional strategies based on building local technology clusters to fuel innovation and the growth of world-class centres across Canada. For 2000-2001, NRC will make significant new investments in Atlantic Canada to help grow knowledge-based technology clusters in genomics, medical diagnostics, ocean engineering, e-commerce, information technology and life sciences. Consultations with communities across the region will culminate in roundtables and community-developed plans for innovation that will act as the "agenda for action" over the short and medium-term.

"Research at the St. Boniface Centre is a symptom of an important element of the life sciences sector; the close collaboration between public sector research institutions and the business community. The success of IMRIS and the other spin-offs [from NRC] shows the importance of bringing together science and business smarts to create a visible life sciences industry. The interconnections between research institutions and business are a strength of the Winnipeg life sciences sector."

Manitoba Business Magazine
June 2000

The NRC Innovation Centre in Vancouver, B.C. – developing core competencies relevant to the long-term strategic technology needs of all Canadian manufacturers, with particular emphasis on integration with other players in the B.C. innovation community.

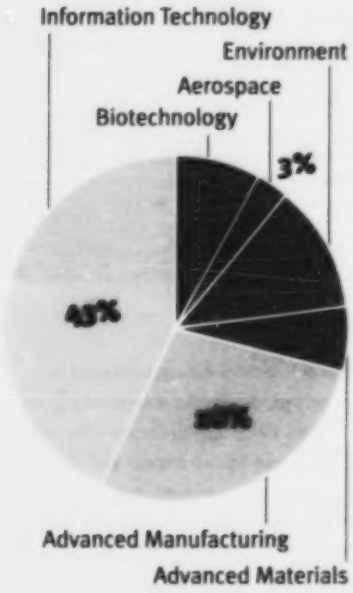
Artist's conception of the new Industry Partnership Wing at NRC's Plant Biotechnology Institute (PBI) in Saskatoon: housing incubator facilities and increasing collaborative research with biotech companies.

Medical technologies advancement in Winnipeg: developing Magnetic Resonance Imaging (MRI) techniques and instruments to diagnose human disease and create protocols to apply these techniques to solve medical and biological problems.

IRAP/CTN: HELPING SMES TURN GOOD IDEAS INTO VALUABLE PRODUCTS AND SERVICES

- **262 Industry Technology Advisors (ITAs) in 90 communities across Canada – from NRC and more than 100 other organizations – covering every industry sector**
- **7 regional offices – connected to all national NRC programs/services**
- **more than 100 co-delivery partners – public and private sector – providing access to S&T expertise in communities across the country**
- **Over 1,000 Canadian Technology Network (CTN) members – providing service to 2,300 clients and supporting participation in 260 trade shows, seminars and other vital networking events in 1999-2000**

IRAP-TPC: CONTRIBUTIONS BY TECHNOLOGY SECTORS



Stimulating innovative capabilities of SMEs

Much of the growth in Canada's economy can be attributed to wealth and job creation by small and medium-size businesses. One of NRC's primary objectives is to link its diverse programs, networks and infrastructure to small and medium enterprises (SMEs) to help them access, develop and exploit technologies.

A major component of this effort is the Industrial Research Assistance Program (IRAP). The role of IRAP is to build and strengthen Canada's innovation infrastructure through a wide array of programs and services. IRAP offers SMEs access to the resources necessary to increase their innovative capabilities and improve their competitive advantage. The Program serves all industrial sectors, matching assistance and advice to each client's specific needs and building on the strengths of the individual firm and the community.

Results speak for themselves
In 1999-2000, IRAP:

- Reached more than 12,000 SMEs in all parts of Canada, with advice and/or financial assistance
- Invested $89.8 million (an increase of 6 per cent over 1998-1999) in 4,343 projects to help reduce the risks small firms face in developing or adopting new technologies
- Provided funding to 3,359 Canadian SMEs on innovation projects
- Participated in more than 350 information-sharing events across Canada and abroad, including workshops, conferences, fora and roundtables
- Identified 281 projects containing elements of eco-efficiency under its Sustainable Development initiative to help SMEs merge environmental concerns with social and economic needs. In addition, IRAP developed a Web-based Design for Environment guide for Industrial Technology Advisors (ITAs) and clients to systematically integrate environmental considerations with product and process design
- Continued to strengthen its presence in Canadian universities, technical and community colleges, reflecting the call of the Advisory Council on Science and Technology for a national strategy to maximize the economic and social returns to Canada of a public investment in university research.

In 1981, Saskatoon's Massload Technologies was a small, local assembler and distributor of weight scales and electronic weight sensors known as loadcells. Today, thanks in part to financial assistance and technical support from IRAP, Massload is the leading manufacturer of loadcells in Canada and a heavy hitter on an international scale.

ORGANIC SOIL REGENERATION

An Alberta company found an innovative solution to the problem of agricultural waste by establishing manure processing plants throughout the province. Their product, an organic soil regeneration and mulch system, will be sold to agricultural and horticultural industries at both the retail and wholesale levels. The company received assistance from both IRAP and CTN.

"CTN and IRAP have assisted in bootstrapping the technology and helping through all phases. Now, Earthrenew is at the stage where it can attract other investors... We're not only making an impact environmentally and appealing to organic produce growers, we'll also be providing new jobs to rural Alberta."

C. Cairn
Company Founder
Earthrenew Organics Ltd.

In-depth analysis

In 1999-2000, IRAP undertook an in-depth analysis of 12 case studies of clients from across the country. On average, these firms have been working with IRAP for about five years. The case studies showed that IRAP helped improve the innovative capabilities of the firms as follows:

- Clients refined their initial vision or changed their innovation culture
- Clients developed additional linkages to sources of technical expertise (and to partner companies)
- Clients increased their in-house technical expertise and capability (e.g. equipment and facilities)
- Clients gained information needed to develop their products/processes (through R&D, technical investigations, etc.)
- Clients gained additional market information or increased financial capability
- Clients decided to continue with the innovation process (i.e. did not give up)
- Clients increased their ability to produce and commercialize products.

International technology missions

By organizing and leading international technology missions, IRAP demonstrates its commitment and willingness to assist SMEs in penetrating the global marketplace and improving their technology transfer competencies. The Canadian Institute for Market Intelligence (CIMI) conducted a three-month study of the nine missions organized to Southeast Asia between 1997 and 1999. Findings of the survey demonstrate that participating companies:

- moved towards international partnering in S&T, market access, technology-based cooperation and exchange
- were very positive about the performance of NRC-IRAP and the individual ITAs assisting them
- found the support network of NRC-IRAP very valuable in making international connections.

A large majority of the participants indicated that the missions contributed enormous value in terms of personal experience and relationship building, financing and revenue generation. The vast majority interviewed indicated their willingness to participate in this kind of activity again.

Special programs address wide-ranging mandates

In addition to regular technological innovation support, the portfolio of IRAP services includes a series of programs with specific and wide-ranging mandates and responsibilities. Other IRAP support programs and their activities in 1999-2000 included:

- **Canadian Technology Network**
  The Canadian Technology Network (CTN) provides pathfinding services to SMEs based on a membership of 1,000 plus innovation-related service providers. In 1999-2000, CTN responded to more than 3,000 simple queries, and provided advisory services to 2,300 clients.

For Manitoba-based Mekiwin Corporation, horseradish represents the promise of a healthy future. IRAP support made it possible for Mekiwin to conduct research into the nutraceutical properties of horseradish and, as a result, the company's capsules are now selling under its own label in about 700 stores in Canada. Continued IRAP support will allow Mekiwin to perfect its standardization process and apply its technology to other sources such as St. John's Wort, valerian, hemp and feverfew.

- **Precommercialization Assistance**
  The five-year Precommercialization Assistance Program, established jointly with TPC/Industry Canada in 1998, provides $30 million annually in repayable financial assistance to Canadian SMEs for technology commercialization projects. In 1999-2000, the program approved 68 new projects for an overall total of 108 projects over that period, an increase of 70 per cent over 1998-1999. The success of this program is attributed to the IRAP network's "on the ground" capacity to understand the needs of SMEs for assistance in getting products into the marketplace and to provide financial help for the early stages of commercialization.

- **Youth Employment Initiatives**
  The Youth Employment Initiatives program provided support to firms to hire recent college and university graduates. Last year, 643 students gained valuable work experience through this program.

- **Technology Visits Program/Innovations Insights**
  The Technology Visits (TVP) and Innovations Insights (II) joint programs of IRAP and the Alliance of Manufacturers & Exporters Canada (AMEC) are designed to facilitate the exchange of best practices among managers who have successfully introduced new technologies and innovative concepts into their operations. Last year, these programs sponsored visits by over 2,100 senior managers to 105 host companies that had successfully introduced new technologies and innovative concepts into their operations.

Improving program services
To improve its services, IRAP:

- Developed and strengthened its national scope while broadening its regional base, with new programs and services in almost every region in Canada

- Developed internal management tools and guides to better serve clients, improve processes in client-related activities, and measure the performance impact of IRAP on the innovative capabilities of SMEs

- Sponsored or participated in numerous workshops and technology conferences, including a biotechnology forum in Toronto with more than 200 participants and a workshop involving 125 representatives from the Canadian aerospace sector

- Established the Strategic Alliances (SA) office to provide SMEs and ITAs with effective access to international expertise, technologies and strategic technology alliances. Through a dual-purpose program, the SA group also made numerous presentations about IRAP's assistance programs to interested visiting delegations from such countries as Sweden, France, Ukraine, U.K., South Africa, Australia, China, Thailand and Taiwan. IRAP is linked to five of the 36 agreements between NRC and other countries including France, Indonesia and Thailand.

Talent for Canada

Excellence in research and innovation in Canada depends heavily on the ability to attract, train and retain highly qualified scientists, engineers, technologists and other professionals. NRC is committed to helping build the critical mass of skilled people that will be fundamental to Canada's success in the knowledge-based economy of the future.

Guest workers

NRC's institutes and centres continue to attract large numbers of guest workers from Canadian and foreign universities, companies and other organizations. In 1999-2000, over 1,000 guest workers were engaged in research projects and activities at NRC. Not only does NRC benefit from the participation of guest workers in collaborative projects, but their home organizations gain equally from the training provided and the transfer of knowledge and know-how.

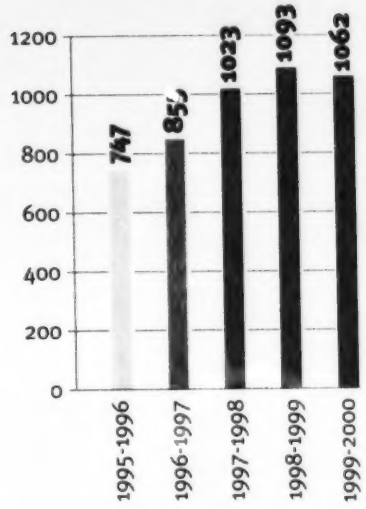
Student programs

In 1999-2000, NRC student programs provided direct hands-on training and development work for many young scientists, involving over 600 graduate, co-op and summer students and nearly 175 post-doctoral fellowships (PDFs). The Women in Engineering and Science Program (WES) continued to encourage talented Canadian women to pursue professional careers in science and to serve as role models. As well, under the APEC umbrella, NRC joined with the Canadian International Development Agency to sponsor six women graduate students from Asian countries to work in institute laboratories.

Next generation scientists

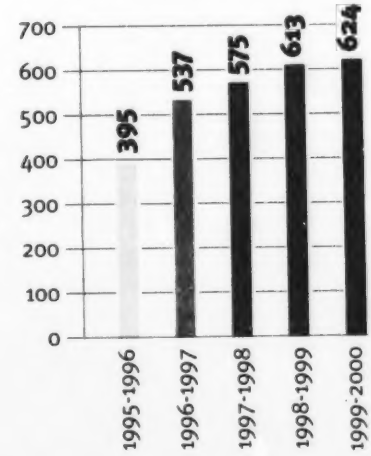
Through 246 adjunct professor appointments in universities and colleges across Canada, NRC researchers contributed to the supervision and training of the next generation of young scientists and engineers.

NRC GUEST WORKERS

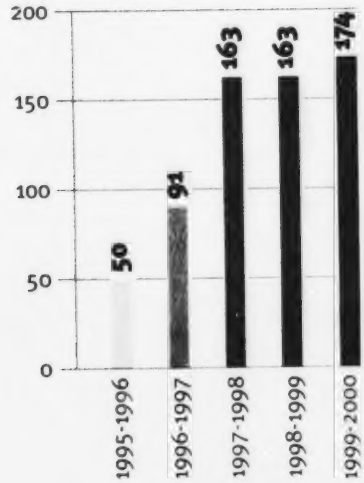


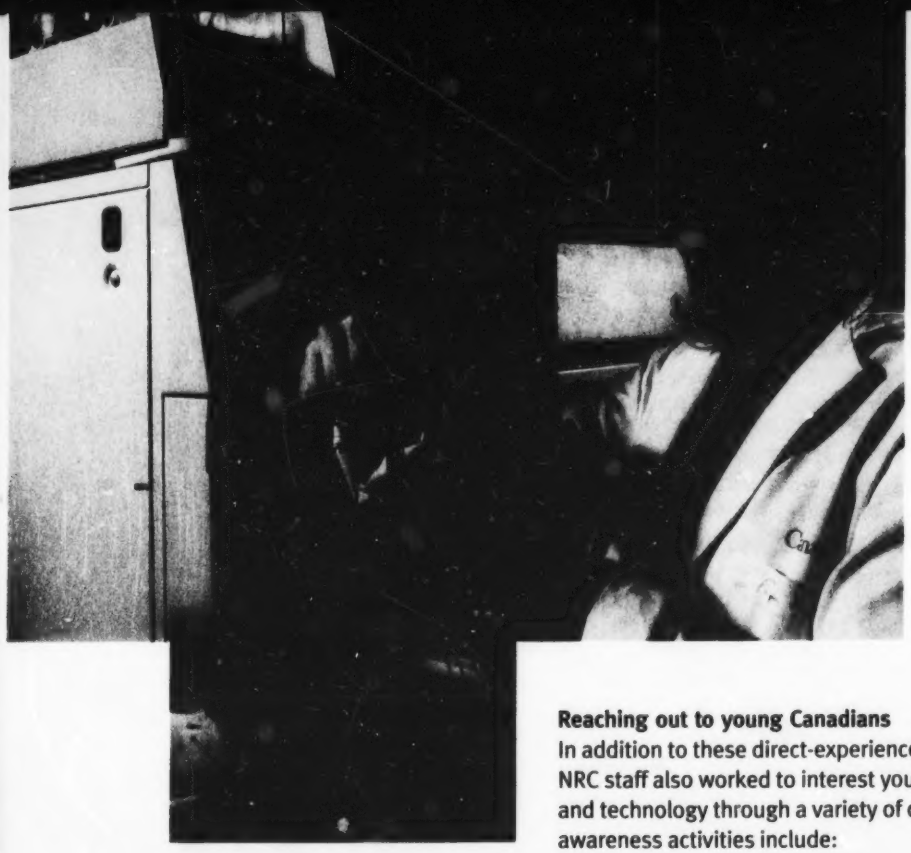
NRC STUDENTS PROGRAMS

(Graduates, Non-grad, Co-op, WES)



POST-DOCTORAL FELLOWSHIPS





Training the next generation: NRC is committed to helping build the critical mass of skilled people that will be fundamental to Canada's success in the knowledge-based economy of the future.

Reaching out to young Canadians

In addition to these direct-experience education and training activities, NRC staff also worked to interest young Canadians in careers in science and technology through a variety of outreach activities. Highlights of public awareness activities include:

- Collaboration with schools and industrial partners in an ongoing Virtual Classroom project to research and develop communications technologies and collaborative distance learning models to improve the education system. This project won NRC and partner Collège catholique Samuel Genest an Ottawa Centre for Research and Innovation (OCRI) award for the *Zero to Space Station in 20 Days* program, which integrates a 3D computer-assisted design unit into a secondary school engineering course
- NRC's *Canadian Skies* poster, featuring a star chart, distributed to over 32,000 school teachers with the help of *Teach* and *Rescol* magazines. NRC also provided thousands of copies directly to educators and Members of Parliament, who in turn distributed some 4,000 posters in their constituencies
- NRC's Institute for Information Technology which worked in collaboration with the National Arts Centre to develop methods for using the Internet to support distance learning. This project will focus initially on adapting technology for distance learning in music
- Direct outreach activities and sponsorships of national events such as "Marsville" and National Engineering Week; the launch of NRC's official countdown Millennium Clock; and facilities tours and demonstrations, including visits by more than one million Canadians to the Herzberg Institute of Astrophysics observatory.

PARTNERING FOR SUCCESS

Innovation on a national scale doesn't just happen. It requires infrastructure, networks, and systems that integrate the efforts of government, business and education organizations.

It requires focused strategies and initiatives to build linkages among key players and support the emergence and growth of new firms and industries.

It requires alliances, partnerships and collaborations – local, national and international – to bring together and leverage the S&T resources needed to create centres of expertise, innovation and global competitiveness.

NRC acts as a key catalyst to stimulate R&D partnerships and collaborations with businesses, universities, and governments, at home and internationally. Its ability to forge stronger linkages amongst all the players helps to fuel the innovation capacities of communities and regions across Canada.

In 1999-2000, NRC "partnered for success" on an unprecedented scope and scale.

Collaborations and partnerships

In 1999-2000, formal collaborations and partnerships with national and international public and private organizations helped drive efforts to leverage resources and foster growth in key technology sectors for Canadian businesses. Here are some of the highlights. Additional examples are highlighted in "NRC's Institutes/Programs" section.

Extensive alliances
NRC implemented 352 new formal agreements in 1999-2000, for a total of 614 active collaborations over that period. An additional 577 formal collaborations were maintained with national organizations and 298 with international bodies. The value of the collaborative agreements NRC signed was over $91 million, with cash contributions from partners totalling more than $35 million. The in-kind contributions of partners totalled almost $33 million.

Collaborating through networks
NRC also extended its networks through work on committees touching every sector of the economy in key R&D and technology areas. In 1999-2000, NRC staff were involved with 557 national committees and 717 international committees.

Federal Partners in Technology Transfer
For a fifth successive year, NRC maintained a strong involvement in the Federal Partners in Technology Transfer (FPTT) – a collaboration of 17 federal science-based departments and agencies working to facilitate the transfer of knowledge and technology developed in government labs to industry in Canada. Three NRC projects were identified by FPTT for having outstanding "leadership, dedication and excellence" in collaborations leading to commercial application of technologies and the advancement of scientific or technical knowledge.

AGREEMENT TURNS IDEAS INTO SOLUTIONS FOR CANADIAN AGRICULTURE

A $10 million, five-year research agreement between NRC's Plant Biotechnology Institute in Saskatoon and Dow AgroSciences Canada Inc. (DASCI) is turning innovative ideas into solutions that benefit Canadian agriculture.

The agreement focuses on the development of better ways to genetically improve canola and other Canadian crops, and to tackle problems caused by insects and disease. Canadian farmers can expect solutions to reduce costs, increase crop production, and increase their ability to compete internationally.

Around the world, research in agricultural biotechnology continues to evolve. Through strong strategic alliances such as this, PBI and DASCI assure Canada's status as an international leader in enhanced crop development and production.

Accurate measurement standards provide Canadian companies with a competitive advantage: the "triple point" of water is the most fundamental of temperature fixed points, and is used extensively in high-accuracy calibrations. A triple point is the unique point on the thermodynamic phase diagram of any substance where all three phases – solid, liquid, and gas – coexist in thermal equilibrium.

Cellphone antennas
NRC worked on the design and testing of cellphone antennas with Globus Cellular, which lead to that company receiving an initial order from Hyundai Electronics for 500,000 units.

High frequency detectors
HIA assembled to standard, and delivered on schedule, two detectors for the receivers used to test the Atacama Large Millimetre Array (ALMA). The high frequency detectors will be critical for validating performance of the prototype ALMA antennas and providing data to optimize the final design. Their delivery also constitutes Canada's first concrete contribution to ALMA and demonstrates the credibility of NRC and Canada to international partners.

Tapping new energy sources
Gas hydrate research, including new structures and inhibition, focuses on the potential of natural gas hydrates as a vast, untapped global energy source that may have a role in global climate change – as a source (or containment) of greenhouse gases. NRC's research is in collaboration with the Geological Survey of Canada and partners from Japan.

New compounds for cancer treatment
Provision of specialized biological and biochemical assays by the Institute for Biological Sciences (IBS) for Isotechnika Inc., were beneficial in helping the firm define lead candidate compounds in cancer treatment for validation in clinical trials.

In a CLAS of its own
The CLAS (Calibration Laboratory Assessment Service) program at INMS, in partnership with the Standards Council of Canada (SCC), continues to develop a network of accredited commercial calibration laboratories across Canada to provide industry with a verified and documented link to national measurement standards. In the past year, CLAS conducted six assessments and seven re-assessments. In addition, five laboratories were evaluated for expansions to the scope of their accreditation.

This means that parts manufacturers, for example, that take advantage of the services of a CLAS laboratory get an advantage in the global marketplace. More and more, good measurement practice and traceability to internationally recognized standards are valued for the crucial role they play in product quality and in the inter-operability of parts. And just as clients of accredited laboratories see their market share grow, so too, do the laboratories themselves, with some realizing a 30% growth since partnering with NRC.

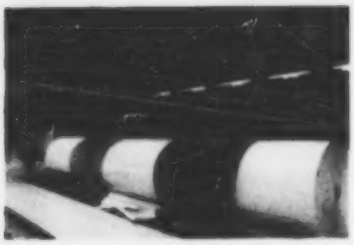
HELP WITH ALMA

"HIA staff were critical in enabling AGRA Coast to bid on the ALMA antenna project. The result will be of great long-term benefit to our company. I have never seen such dedication to getting something like this done by any government agency."

David Halliday
Vice President, Director of Special Projects
AGRA Coast

"Clients choose CLAS assessed laboratories because they are interested in pushing precision calibration to its highest level and want to be associated with like-minded businesses. These two things seem to go together – an interest in quality and an interest in business excellence."

Anthony Ulrich
Vice-President
Ulrich Metrology Inc.



METROLOGY: THE INVISIBLE "INFRASTRUCTURE" PAYS OFF FOR CANADIAN INDUSTRY

Metrology, the science of measurement, is strategically important both for attaining scientific excellence and for helping Canadian industry compete in the global marketplace. Physical and chemical measurements – traceable to internationally accepted standards – enable mass production, facilitate trade, enhance quality, and increase consumer confidence.

In 1999-2000, NRC's Institute for National Measurement Standards used diplomacy and sound science to resolve a disagreement between Canada and Europe concerning pulp-brightness measurement techniques. As the world's largest exporter of pulp, the discrepancy could have had severe consequences for one of Canada's largest industries.

The outcome? The agreement reached on measurement techniques has saved the Canadian paper industry some $100 million per year in extra bleaching costs... not to mention the environmental benefits of the industry using less bleach in order to sell its products in Europe.

"The accurate measurement of optical properties is crucial to the terms of sale for most of our industry's products. In fact, ISO brightness is the key specification in any commercial agreement on the purchase of bleached/semi-bleached market pulp, of which Canada is the world's leading exporter."

Mr. W. Wood
Executive Director
Pulp and Paper Technical Association of Canada (PAPTEC)

Working on the world stage

International activities by NRC serve many purposes. They provide access to the international marketplace and help increase Canada's global competitiveness, by building on and initiating new strategic partnerships and agreements that benefit Canadians. By opening these international gateways, Canada gains entry to the tremendous wealth of information and technology the world has to offer. In addition, NRC is able to:

- leverage its resources through collaborations with other leading laboratories
- establish its credibility, as well as Canada's, on an international level
- build relationships to provide opportunities for Canadian firms.

Highlights of NRC's international activities for 1999-2000 included:

Workshop on the future of manufacturing
An MOU in the field of manufacturing technologies signed between NRC and the U.S. National Science Foundation enabled a bi-lateral workshop to develop an Integrated Manufacturing Technology Roadmap – leading to the first National Science Foundation Design and Manufacturing Research Conference ever held in Canada.

Strengthening ties with France and the U.K.
NRC currently has 6 joint collaborative projects ongoing with the United Kingdom through the NRC/British Council Joint Science and Technology Fund, and 10 joint collaborative projects with the Centre National de la Recherche Scientifique (CNRS) of France.

In one UK project, NRC's Steacie Institute for Molecular Sciences is collaborating with the University College of London on the organic modification of semiconductors. In one of the projects with France, NRC's Institute for Biological Sciences and CNRS are researching calcium-induced genes in ischemia and epilepsy. NRC expects both of these projects to produce long-term benefits and advances in their fields.

NRC and Taiwan collaborate
NRC undertook six collaborative projects and held a similar number of workshops in collaboration with the National Science Council of Taiwan, in areas including microelectronics, nanoelectronics, chemistry and biotechnology. An MOU covering intellectual property and specific collaborations with the Industrial Technology Research Institute of Taiwan in industrial materials and nanoelectronics was also signed.

Biochips in Singapore
In Singapore, NRC and the National Science and Technology Board launched several collaborative projects in the areas of biotechnology, biochips, aerospace, and materials design.

Mission: successful
NRC led a technology mission to China for academic and business development, at the invitation of the Chinese Academy of Sciences. As a result, eight companies have signed cooperation agreements or sales agreements with their Chinese counterparts.

New protocol for cancer clinics
The TG-51 Protocol for Clinical Radiotherapy Dosimetry, mainly written at NRC and based on NRC work, has been recommended for use in all cancer clinics in Canada and the United States. Within 2 years, virtually all North American clinics will be applying this dosimetry protocol to the benefit of some 600,000 patients annually.

Commercialization: moving technology to the marketplace

An essential step in the innovation process is moving discoveries out of the lab into the market. NRC uses a variety of methods to commercialize its intellectual property, including licensing, spin-offs and collaborative agreements.

Commercialization highlights for 1999-2000 included:

Technology licensing
NRC issued 78 licenses for its technologies, and received just over $2.1 million in licensing revenues.

Skin health revolution
Nuvo Intraceutical, a spin-off from NRC's Institute for Biodiagnostics (IBD), is commercializing near-infrared skin assessment technology developed in IBD. This new technology has the potential to revolutionize the way medical staff can assess skin health and recovery from surgery.

Living skin replacement
Apligraf, along with NRC spin-off company IatroQuest, is developing living skin replacement technology licensed from NRC. The company expects first generation products to enter clinical trials in 2000-2001, with second generation products to be developed in incubator space at the Institute for Biological Sciences (IBS).

Artificial intelligence monitors air fleet
Mxi Technologies Ltd. was selected to commercialize and market NRC's Integrated Diagnostics System technology developed collaboratively by our Institute for Information Technology (IIT), Air Canada and General Electric. This technology uses artificial intelligence to monitor the health of Air Canada's Airbus fleet, in flight, and to recommend the most efficient repair and maintenance procedures.

Bleaching enzymes for pulp
Leveraging IBS expertise, Iogen Corporation (a pioneer in the use of bleaching enzymes in the Canadian pulp and paper industry) has commercialized second generation enzymes with enhanced operating ranges – greater tolerances to the pH and temperature levels needed by most pulp mills. Thanks to these modified enzymes, mills are moving toward elimination of chlorine bleach, reducing the toxic discharge of organochlorines into Canadian waterways by several hundred tonnes per year.

"The Integrated Diagnostic System is really industry leading. We have a product here that quite frankly will be a world beater, something no other airline has right now. By the end of the year we will have the IDS system installed in every aircraft maintenance station across Canada. This is truly a remarkable development..."

Dave Ramage
General Manager – Line Maintenance
Technical Operations
Air Canada

Around-the-clock space vision system
Neptec, an Ottawa-based high technology company and NRC spin-off, developed a real-time target tracking system based on IIT's synchronized scanning laser range finder technology, which it demonstrated to the Canadian Space Agency and NASA. Immune from the effects of sunlight, this new system will allow the new space vision system to be operational virtually 100 percent of the time. The results: improved efficiency of space station assembly; new geometric documentation and inspection capabilities; and over $30 million in contracts with NASA reported by Neptec.

Advanced energy systems
Since 1997, NRC and Energy Ventures Inc. (EVI) have focused on technology for the development of advanced energy systems – specifically, lithium ion batteries. The agreement has expanded to include Pacific Lithium Ltd. (of New Zealand) as a sub-licensee, to develop a series of lithium ion battery cathode materials discovered by NRC researchers. The market value for these materials is forecast to increase by 50 percent per year by 2002, with the global market for lithium ion batteries expected to reach U.S. $10 billion by 2005. Reducing the costs of high performance rechargeable batteries will extend their potential use in new applications, possibly even to electric vehicles.

New software product line
A syndicated knowledge management study involving IIT and the Centre international de recherche en infographie (CIRI) provided CoRedge Software with new insight into knowledge management requirements and impacts on their product lines. As a result, CoRedge has developed a series of new products under its *Knowledge Service Providers* software suite.

"Explosive" soil decontamination technology
Biogénie Incorporated, an international bioremediation company based in Québec, licensed a new process developed at the Biotechnology Research Institute in partnership with the Department of National Defence for treating soils contaminated with chemicals from explosives.

Bright light – better quality
Raytheon ELCAN Optical Technologies is using polarization recovery technology developed at the Institute for Microstructural Sciences (IMS) to recover light normally lost within projection display systems. This new technology allows Raytheon ELCAN to enhance the brightness of their projection systems, increasing the quality of their product.

SiGe technology
IMS developed SiGe technology to the point where the highly successful spin-off company, SiGe, became a sustainable business venture. The technology is used in high speed bipolar transistors for wireless components. SiGe itself eventually split into two companies, SiGe Microsystems and SIGEM, both of which have prospered. The two companies now employ 200 people and each has a market capitalization beyond $100 million. SiGe Microsystems recently graduated from the NRC-run Industrial Partnership Facility (IPF) to new facilities in the west end of Ottawa.

New firms – new ventures

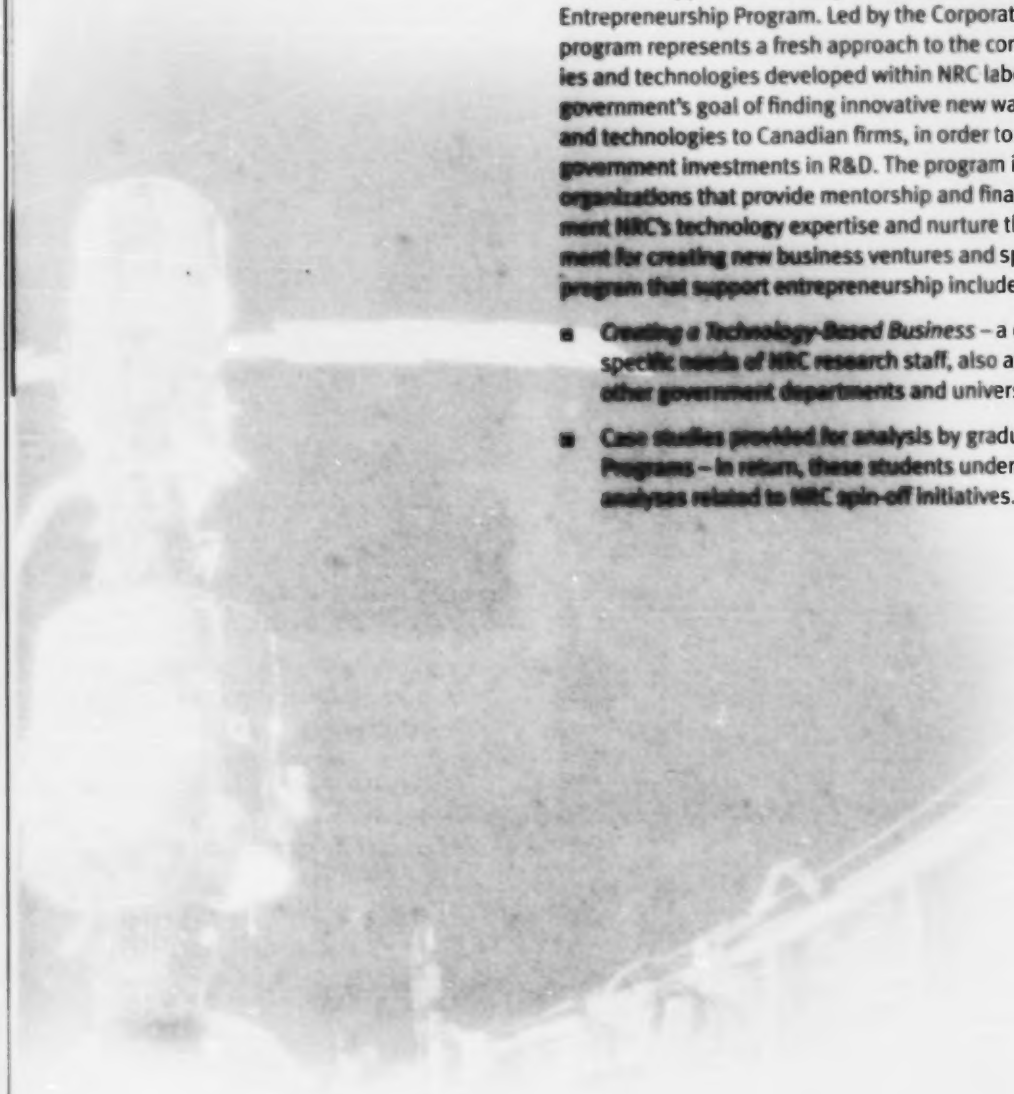
In 1999-2000, NRC generated or assisted in the establishment of 21 new companies. Seven of these were founded entirely by NRC researchers who became private sector entrepreneurs – with NRC's support – in order to commercialize their work:

- nir-vivo incorporated
- Hydrogeo Plus
- HMI Incorporated
- Megatech Simulation
- Pharmgap
- Biochip Facility Incorporated
- UTEX Scientific Instruments Incorporated

Entrepreneurship Program

NRC also supports the emergence of new companies through its Entrepreneurship Program. Led by the Corporate Services Branch, this program represents a fresh approach to the commercialization of discoveries and technologies developed within NRC laboratories. It underpins the government's goal of finding innovative new ways to transfer discoveries and technologies to Canadian firms, in order to magnify the impact of government investments in R&D. The program is strongly linked to several organizations that provide mentorship and financial assistance to complement NRC's technology expertise and nurture the best possible environment for creating new business ventures and spin-offs. Other aspects of the program that support entrepreneurship include:

- *Creating a Technology-Based Business* – a course tailored to the specific needs of NRC research staff, also attended by employees of other government departments and universities
- Case studies provided for analysis by graduate students in MBA Programs – in return, these students undertake market research analyses related to NRC spin-off initiatives.



KNOWLEDGE: THE NEW CURRENCY

Knowledge has often been called the new currency of the global economy. In today's world, the creation of new knowledge and information, and their effective dissemination and transfer, are just as vitally important to the economy as physical infrastructure and financial capital. NRC makes major contributions to both the creation of new knowledge and the dissemination of S&T information to the Canadian scientific and industrial communities.

New knowledge for Canada

NRC's ability to create and disseminate knowledge can be demonstrated in a number of ways. Publications in peer reviewed journals are one measure; patents are another. Each idea or technology that secures a patent represents an original and useful innovation that has taken its first steps toward marketability. In 1999-2000, NRC maintained some 600 active patents, made over 200 new patent applications, and secured a total of 70 new patents.

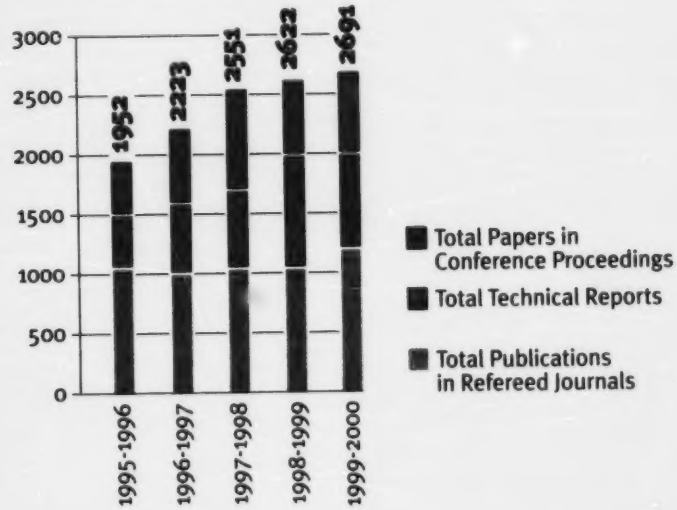
There are other performance indicators as well. In 1999-2000, NRC staff:

- Published in excess of 1,000 articles in refereed journals, including articles published in 2 of the highest ranked scientific journals – *Science* and *Nature*
- Presented some 1,935 papers at conferences around the world, with nearly 1,000 published in conference proceedings
- Produced over 500 technical reports
- Served on the editorial boards of some 129 science and technology journals.

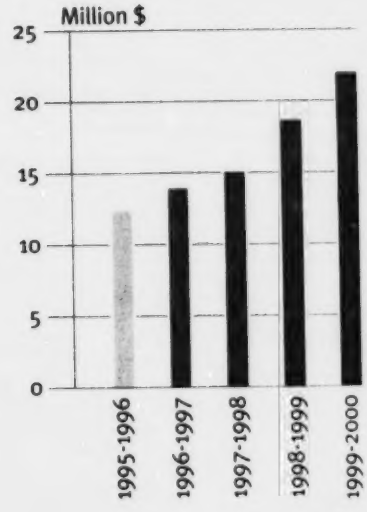
"Canada's competitiveness depends in large part on our ability to innovate and rapidly exploit science and technology breakthroughs. Our nation's ability to access and diffuse knowledge and information, and to convert knowledge through innovation into new products for the global marketplace, have become critical factors for economic growth."

Jacques Lyrette
Vice President
Technology and Industry Support, NRC

NRC PUBLICATIONS

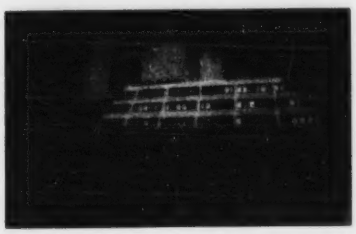


CISTI REVENUE GENERATION



ACCESS TO THE WORLD'S INFORMATION RESOURCES

New resource partnerships with the Institute for Scientific and Technical Information of China and Sunmedia of Japan increase access for Canadians to the world's STM information. These new agreements complement the links already established with the British Library, the Canadian Agriculture Library, and the Science and Technology Information Centre of Chinese Taipei.



CISTI is increasingly viewed as a key component of Canada's S&T information infrastructure.

Vital information infrastructure for Canada

As Canada moves from a resource-based to a knowledge-based economy, both the systems and requirements for managing information are undergoing profound changes. In this environment, the role of NRC's Canada Institute for Scientific and Technical Information (CISTI) as the nation's major scientific, technical and medical (STM) information resource has assumed a steadily growing importance. The Institute is increasingly viewed as a key component of Canada's S&T information infrastructure.

Through its dual function as STM library and scientific publisher, CISTI maintains, publishes and provides access to the STM information resources essential to the Canadian research, industry, and health communities. To effectively fulfill its role, CISTI has undergone significant transformation to address the latest technologies and opportunities available today in information management and dissemination.

Major initiatives undertaken by CISTI to enhance access and service in 1999-2000 included:

Five-year strategy
CISTI launched a new five-year strategy to 2005, aligned with Canada's S&T agenda and needs, with a mission to safeguard, enrich and leverage STM information assets of national importance.

CISTI Source
The Institute launched CISTI Source, a current awareness service that provides online access through the Internet to over 10 million articles in agriculture, engineering, biosciences, and other disciplines. Alerting features bring the latest information to researchers and innovators as soon as it becomes available.

Publication alert service
The Institute introduced a new publication alert service for the NRC Research Press electronic journals that notifies clients by e-mail when a new issue or article is released on the Internet.

Electronic publishing services
The NRC Research Press provides electronic publishing services to assist not-for-profit societies to offer their journals on the Internet. The Mineralogical Society of Canada and the International Society for Plant Molecular Biology joined the growing list of societies that benefit from this program.

Increased reach for NRC Research Press
NRC Research Press publications are now available through Net Library – a service delivering electronic books over the Internet – and through PubScience, a system that allows users to search papers from some 500 scientific and technical peer-reviewed journals.

New ventures
CISTI also ventured into new territory, undertaking initial stages of development for a Competitive Technical Intelligence (CTI) service as part of its new strategic direction. Over 3,000 firms were surveyed regarding their CTI practices. Focus groups held across Canada helped to formulate a roadmap for government support of CTI for Canadian industry. In 2000-2001, CISTI will continue to promote CTI activities in association with IRAP and CTN.

DISCOVERY: ADVANCING THE FRONTIERS

NRC is first and foremost a research organization. Its core business is medium to long-term science and technology research. This is the foundation for NRC's contributions to the advancement of knowledge, to industry, and to social and economic prosperity for Canada.

During 1999-2000, in the areas of research and development, NRC maintained its major long-term strategic research investments and generated new R&D initiatives in fields such as: genomics, fuel cells, photonics, electronics, aerospace, advanced manufacturing and materials, astronomy, biotechnology and environmental technologies. It also pursued new crossover R&D programs to bring together multiple disciplines – bioinformatics, high performance computing, molecular electronics, nanostructures and others – to begin tapping tomorrow's technology opportunities today.

Advances in basic sciences

Astronomy and Astrophysics – Our gateway to the Stars

NRC's Herzberg Institute of Astrophysics (HIA) carries out leading-edge research in astronomy and provides access to major facilities in Canada and overseas, allowing Canadian scientists to address fundamental questions about the cosmos that help us understand the evolution and workings of the universe.

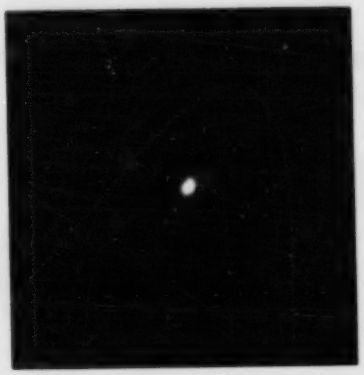
New class of cold clouds
The discovery of a new class of cold clouds of atomic hydrogen gas in the interstellar medium (ISM) is providing insight into the physics and chemistry of the ISM and improved understanding of physics at very low densities.

Six degrees of freedom
The invention of an innovative mechanism providing six degrees of freedom for accurately positioning small components, such as precision optics, offers potentially widespread applications in devices for the optical and precision mechanics industries.

Molecular Sciences: Small Scale – Big Impact

The Steacie Institute for Molecular Sciences (SIMS) focuses on pushing forward the frontiers of molecular sciences to provide the foundations for technological development in the years ahead.

Next revolution in microchip tech
Using ultra-high vacuum scanning tunnelling microscopy to manipulate atoms and molecules on silicon surfaces, SIMS is laying the foundation for development of micro-scale electronic devices. This molecular-scale analogue of lithography involves the development and refinement of self-directed, self-limiting chemical processes on silicon. By promoting organic molecules to line up spontaneously along natural pathways on a silicon crystal, scientists have taken a key step toward the next revolution in microchip technology – the fabrication of tiny devices that sense, analyze and respond to information in their environments.



CHARTING THE COURSE OF CANADIAN ASTRONOMY

HIA played a key role in the formulation of the Long Range Plan for Astronomy in Canada co-sponsored by NSERC and NRC. A representative panel prepared the plan, in full consultation with the Canadian astronomy community, charting the course of the discipline for the next 15 years. It defines the key priorities and critical investments Canada must make in response to the central research challenges, the opportunities for future international partnership, and the goal of maintaining and enhancing our reputation for astrophysics research, and instrument and software development.

MOLECULES ALL IN A ROW

"Self-directed growth of molecular nanostructures is one form of self-replication that is essential for the realization of molecular devices. This represents a distinct advance in nanoscale devices."

Calvin F. Quate
Professor, Electrical Engineering
Stanford University

By prompting organic molecules to spontaneously line up along natural pathways on a silicon crystal, scientists at NRC's Steacie Institute for Microstructural Sciences (SIMS) have taken a key step toward the next revolution in microchip technology: the fabrication of tiny devices that sense, analyze, and respond to information in their environment.

Fluorescence imaging of the heart during open heart surgery – resulting in better outcomes and higher survival rates.

Molecules as devices
SIMS has developed new methods to control molecules in space and time that could lead to the use of molecules as devices, such as switches in molecular-scale electronics.

Better disease diagnosis
Development of a new cryogenic storage and transport system for highly polarized (HP) Xenon gas makes it feasible to transport HP Xenon from a central production facility to end users in hospitals, research labs and universities for use in MRI applications. The result is improved quality, faster images, and better diagnosis.

Better disease treatment
Oxidation stress-induced damage to biomolecules and tissue plays an important role in most chronic and fatal diseases, as well as in the ageing process. SIMS is working to identify the species responsible for oxidization stress and to quantify their reactivity. Understanding which reactive intermediaries are involved offers hope of controlling their harmful effects. Researchers also have developed a two-step treatment to restore intercellular communication efficiency and block the growth of cancer cells – leading to a potential cancer treatment drug for the pharmaceutical industry.

Advances in biotechnology

Biotechnology is one of the most important fields of R&D in Canada for the 21st century and a major research area for NRC. NRC's five biotechnology institutes form a strategic Biotechnology Group, working together to tap the potential of a field forecast to have an impact on 25 per cent of Canada's GDP within the next two decades.

Individually, collectively and in collaboration with outside public, university, and private organizations, the Biotechnology Group made several major R&D breakthroughs in 1999-2000:

New tool for surgeons
New technologies for fluorescence imaging of the heart and surrounding arteries during open heart surgery are allowing surgeons to assess blood flow to and from the heart while the chest is still open. This means the doctors can immediately assess the success of surgery, resulting in better outcomes and higher survival rates.

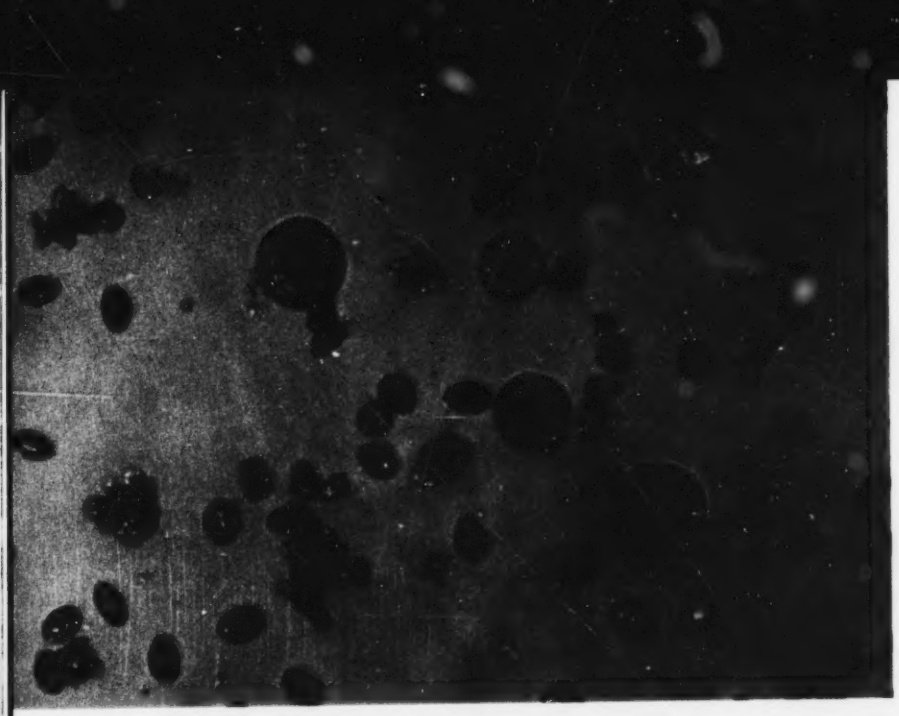
Fewer surgeries, better results
Newly licensed technology from the Institute for Biodiagnostics (IBD) for near infrared assessment of skin will revolutionize how medical staff assess skin health and recovery from surgery, by allowing them to intervene earlier in cases where surgery was initially unsuccessful and by reducing the number of repeat surgeries required.

CHOLESTEROL BREAKTHROUGH

A collaboration involving several Canadian research organizations, including IMB and Xenon Genetics Inc. discovered the cause of two genetic diseases involving low-levels of high density lipoprotein (HDL cholesterol) – Tangiers Disease, which kills people at a young age, and cardiovascular disease. As a result, Xenon received $13 million from a U.S. venture capital firm to help advance its drug discovery platform and programs. Xenon also signed an $87 million agreement with Warner Lambert to develop a drug that will raise HDL levels. This is the largest single pre-clinical collaboration in Canadian biotechnology history.

Drugs that reduce "bad" cholesterol produce $8 to $10 billion in annual sales. No drug yet exists, however, to raise "good" cholesterol (HDL) levels. Development of this drug is expected to find an even greater market.

IMB continues to work with Xenon, having signed two agreements to use its DNA sequencing and bioinformatics expertise to support identification of other genes that control cholesterol, as well as genes involved with other diseases such as diabetes, arthritis, and osteoporosis.



Methods developed for tissue culture and regeneration in nutraceutical plants like St. Johns Wort (pictured here) and Echinacea will help standardize active ingredients.

Identifying cancer markers to create antibody-based drugs: end-on representation of the extended helical epitope of native a2-8 polysialic acid (left) and its biochemically-engineered analog (right). Expression of the latter on tumor cells introduces on their surface a distinguishing and highly cytotoxic tumor marker.

Hope for osteoporosis sufferers
Researchers' efforts to develop unique analogues of parathyroid hormone (PTH) for the treatment of osteoporosis resulted in a patented lead compound that is nearing completion of pre-clinical trials. This project shows great potential to produce a product that will reduce the staggering social and economic implications of osteoporosis for our health care system and improve the quality of life of Canadians suffering from the disease. The venture involves partners in the Arthritis Networks Centres of Excellence, has many leading international collaborators, and has lead to the formation of a start-up company – ParaTech Therapeutics.

Designer antibodies for cancer treatment
Institute for Biological Sciences (IBS) researchers are using molecular biology to create and design antibodies and phage display libraries for use in the development of diagnostic and therapeutic reagents. The major focus is to identify cancer markers and develop cancer immunotherapeutics. The project is leading to promising new antibody-based drugs for the treatment of cancer and other diseases, and for the use of antibody libraries for target identification.

New fish industry on the way
New technology developed at the Institute for Marine Biosciences (IMB) has improved the hatching and raising of haddock larvae, helping major salmon producer Connors Brothers to diversify into haddock as a new aquaculture species for Canada.

Salmon get help
Microtek International Ltd. (B.C.) gained approval, for use in Canada and the U.S., of a vaccine developed at IMB to protect Atlantic salmon against infectious salmon anaemia – a disease that has caused widespread losses in the salmon fishery. In 1999 alone, some one million salmon infected with the disease had to be culled.

DNA vaccines one step closer
NRC's Biotechnology Research Institute (BRI) produced a new adenoviral vector that is ideally suited for anti-cancer therapy and vaccination applications. Researchers are also working to develop targeted viral vectors capable of delivering genes to specific tissues and cell types within the body – key steps for DNA vaccines and gene therapy-based anti-cancer strategies.

Biodegradable plastics
In collaboration with a small biotech firm, BRI has worked on initial development of a fermentation process for production of biodegradable plastic from agri-food by-products. This could result in new biodegradable plastic products and new medical devices.

Better feeds – less pollution
Researchers at the Plant Biotechnology Institute (PBI) have made discoveries in carbohydrate modification – a method to reduce the formation of phytate in plant seeds – an anti-nutritional factor that reduces the use of seed meal in animal diets and is a key component of phosphorus pollution from animal wastes. This discovery could make canola competitive with soybean for both oil and meal markets.

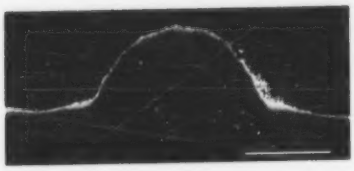
Nutraceuticals get a boost
PBI researchers have also developed methods for tissue culture and regeneration in nutraceutical plant species like St. John's Wort and Echinacea. This work could benefit nutraceutical industries through development of new plant species having standard, characterized active ingredients.

Advances in information and communications

The information and communications technologies sector is significant in Canada. This sector contributed over $43 billion to Canadian GDP in 1999, an increase of more than 20% over 1998, and over four times the overall Canadian 1999 GDP growth rate of 4.3%. Software, hardware, computer services, information processing, and distribution and management technologies all represent fast-paced areas with relatively short technology and product life cycles. As information and communications technologies continue to permeate all aspects of the economy and all fields of research and development, NRC's research institutes are serving an increasingly vital cross-sectoral role.

1999-2000 saw major advances across this sector in 3D digital imaging and modelling, artificial intelligence, and fundamental enabling and next generation technologies, including:

Multi-band infrared range chips
The Institute for Microstructural Sciences (IMS) has developed and demonstrated advanced infrared imaging devices based on quantum well infrared photodetection and light-emitting diode integration. Quantum well detectors in the infrared range can be tuned to almost any band of interest and can be made wideband or switchable multi-band on the same chip. Such multi-band chips are essential for development of effective infrared imaging tools for defence applications, space applications, remote sensing, and environmental and natural resources monitoring.



QUANTUM DOTS: THE FUTURE, NOW

Quantum dots can be used in semi-conductor lasers. Because they dissipate less heat, they can be packed tightly together, forming arrays and ultimately small devices. Researchers hope to use these highly efficient lasers to transmit data more effectively and at higher rates through optical fibre networks. A longer-term projection anticipates the use QDs in improved optical memory.

If realized, an incredible amount of information could be contained in a single device and programmed to interact with other devices. The implications are staggering – a world where the computing power of several present-day computers could be consolidated in one very small unit, affordable to all.

Quantum dot transistor

Refinements made at IMS to the design of a lateral quantum dot transistor have resulted in devices where the number of electrons in a transistor can be controlled. Future markets for this research include laser detectors and optical memories for the IT sector. This technology will also be the building block for the future generation of computers – the quantum computer.

Semi-conductor nanostructures

Working with researchers from the University of Wurzburg, researchers at IMS made breakthroughs in understanding the electronic properties of semi-conductor nanostructures. These nanostructure-confining carriers will play a crucial role in technologies for electronics and photonics – including the next generation of lasers.

Virtual mining

Researchers at the Institute for Information Technology (IIT) successfully demonstrated the operation of mining equipment in Edmonton – controlled over the Internet from its virtual reality theatre in Ottawa. This system integrates information from different sources to allow perception of complex situations and the remote control of equipment. The project was funded by PRECARN, in collaboration with Petro Canada and Syncrude.

If the shoe fits...

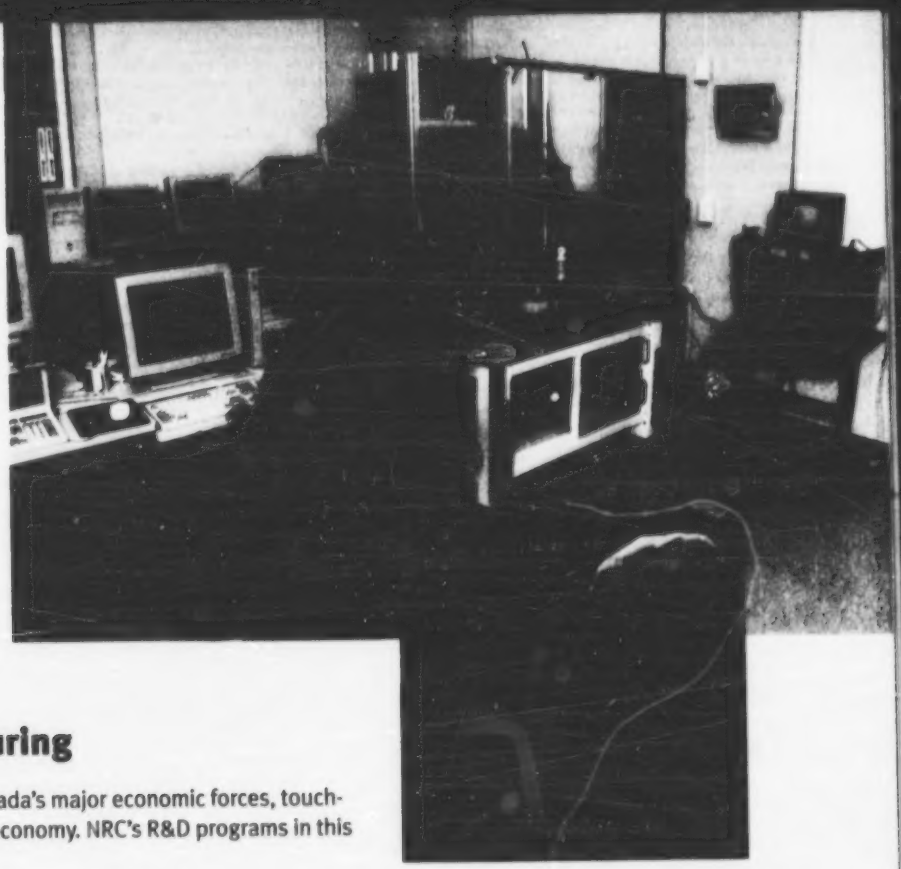
IIT researchers also worked on development of content-based information management tools at the heart of the Civilian American and European Surface Anthropometry Resource (CAESAR™). Some 9,000 people will have their measurements digitized in this project, which seeks to make anthropomorphic information useful to industrial workplace design, automotive design, apparel sizing, protective equipment design, safety assessment and other fields.

Toward secure e-commerce

IIT researchers developed a JAVA-based framework for software agent development, deployment and commercialization, which will result in specifications for digital intellectual property protection. This has enormous potential for companies working in the area of secure knowledge management, including e-commerce applications.

Biochip/IT match holds promise for medicine

A collaborative IIT-IBS project to perform research and develop data mining tools and techniques to be applied to genomics and biochip research was started in 1999-2000. This project has the potential to revolutionize medical screening, improve primary prevention and contribute to more effective treatments.



NRC's Integrated Manufacturing Technologies Institute (IMTI) in London: developing novel, laser-based micro-machining manufacturing processes for biomedical devices that have the potential to substantially improve neurological procedures.

Advances in manufacturing

Manufacturing remains one of Canada's major economic forces, touching virtually every sector of the economy. NRC's R&D programs in this area are focused on:

- Helping the manufacturing community maintain its global competitiveness
- Improving the commercial viability of products and services
- Responding to and adapting new technologies, materials and processes
- Meeting environmental responsibilities.

1999-2000 highlights in manufacturing included:

Cleaner, sustainable production
The Institute for Chemical Process and Environmental Technology (ICPET) has established a new hardware and software platform for assessing the environmental and sustainable performance of technology in areas such as bioethanol production, enzyme bleaching in pulp and paper processes, and fuel cells. Ultimately, this competency could increase the global competitiveness of Canadian industry as cleaner production and sustainable development become mandatory for participation in supply chains.

Manufacturing Innovation Strategy
NRC released *Manufacturing Innovation: An Impact Strategy for 2000-2005* in 1999. Close to 350 people, from more than 150 organizations participated directly in industry technology workshops and strategy development sessions. The Strategy provides the Canadian manufacturing industry with a useful tool for enhancing its global competitiveness.

Faster, better, cheaper processes
Research by the Integrated Manufacturing Technologies Institute (IMTI) has demonstrated the feasibility of economically developing production moulds that are cast in tool steel. This has the potential to reduce the time it takes to make moulds and dies by a significant amount – up to 80 percent – while increasing design flexibility. This offers a dramatic opportunity for the tool and die industry that produces some $4 billion annually.

Laser-machined brain sensor for surgery
IMTI researchers are developing novel laser-based micro-machining manufacturing processes for biomedical devices that have the potential to revolutionize that industry. An example is a collaborative project to develop a new type of electrode for neurological surgery that has laser-micro-machined electrical contacts one-third the diameter of a human hair. If successful, the electrode will produce major improvements in neurological procedures. The enabling technology is a unique ultra-high precision, computer controlled system for laser machining also being developed at IMTI.

Virtual design for U.S. $6 billion vehicle contract
GM Diesel Division in London, Ontario used IMTI's Virtual Environment Technology Centre and research staff to produce and verify the conceptual design of their military vehicles. The design assistance and virtual product demonstrations formed an essential part of the firm's proposal to the U.S. military that secured a U.S. $6 billion contract.

PVC prediction improves quality
The Industrial Materials Institute (IMI) helped a Montréal firm improve the quality of its products through use of online ultrasonic characterization technology. This technology improved the quality control of the firm's PVC (polyvinyl chloride) door and window production by predicting their strength and impact resistance as they are being produced.

More product from fewer trees
Simulation experiments and finite element modelling by NRC's Innovation Centre in Vancouver are providing new insights into the woodcutting mechanics of various B.C. wood species and wood composites. This research holds promise for more efficient wood and wood composite machining technology – resulting in more product from fewer trees.

Less paint – cleaner environment
The Innovation Centre is also researching the wear and other surface characteristics of novel, chemically bonded sol-gel alumina-based composite coatings. In collaboration with the Program for Energy Research and Development (PERD), the University of British Columbia, and NRCan's Canadian Lightweight Materials Research Initiative (CLiMRI), researchers are testing optimal new coatings for use on fuel cell systems and auto parts that could potentially replace solvent-based paints.

Advances in aerospace

Air transportation is a global industry, a critical driver of technology, and a vital component of many national economies. Canada's aerospace industry is one of a handful of fully integrated industries in the world, with complete capacity from design and development through manufacture and after-sales service. NRC's Institute of Aerospace Research (IAR) is dedicated to supporting this vital industry through research, innovation support and assistance for the development, commercialization and implementation of leading-edge aerospace technologies.

Key R&D contributions from IAR in 1999-2000 included:

Improving air passenger safety
Development of an airborne radar system for cloud profiling, and evaluation of a new aircraft-icing sensor, will lead to improved safety for passengers travelling by aircraft. IAR collaborated with Transport Canada, Environment Canada, Rosemount Aerospace, NASA, and others on the project.

Reducing aircraft icing
A team from IAR completed more than 90 test-flight hours as part of an international research project with partners in the Aircraft Icing Research Alliance. This work will lead to improvements in icing forecasts and better understanding by pilots of the areas and altitudes where atmospheric conditions make ice more likely to form on an aircraft.

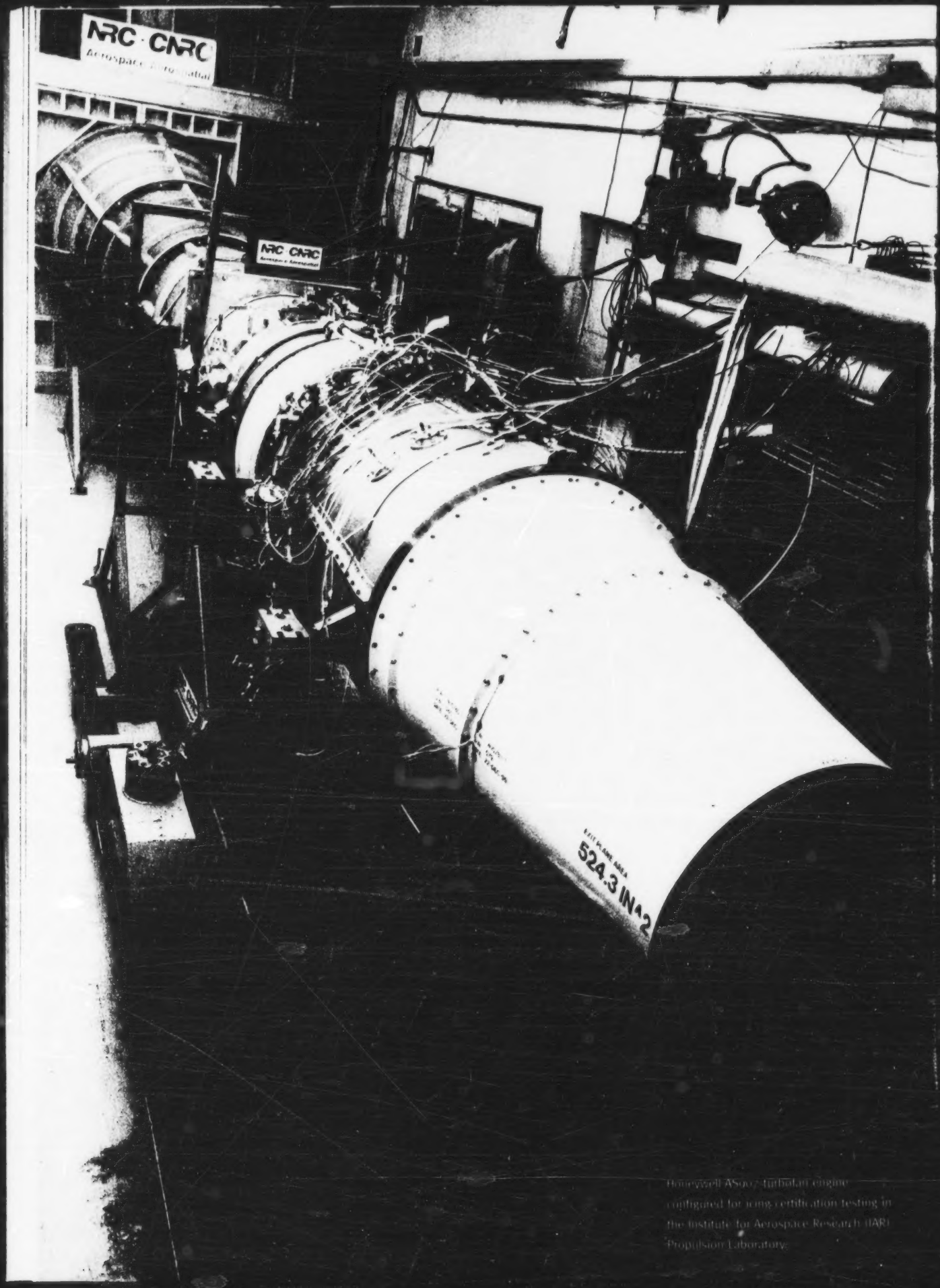
Certifying new engine worth millions
IAR also successfully completed icing certification tests on a new engine for U.S. manufacturer Honeywell and Canadian partner Magellan Aerospace. The engine will be installed in a new Bombardier aircraft, the Canadair Continental Express Business Jet. The testing will result in millions of dollars worth of business for partnering firms.

Detecting toxins in flight
IAR researchers worked with the Mining Association of Canada, Ontario Hydro, Noranda and the Meteorological Association of Canada to develop in-flight methods to detect the presence of metals, gases and particulates in the plumes of coal-fired generating stations and smelters. This is the first time such measurements have been made during flight. The research will lead to a better understanding of toxic substances and how they disperse in the environment.

"FEROCIOUS" MULTI-TASKING

"We have been amazed at the number of test hours we've been able to get in a day. Everyone here multi-tasks ferociously. We got the engine out of the box and running in one week – which is unheard of – and it meant we didn't miss the icing window."

Ron Goodwin,
Engineer
Honeywell



Honeywell AS907 turbofan engine configured for icing certification testing in the Institute for Aerospace Research (IAR) Propulsion Laboratory.

Advances in ocean engineering

NRC's Institute for Marine Dynamics (IMD) works with marine regulatory bodies, marine systems designers, constructors and operators, and the defence community to ensure that Canada's ocean engineering businesses and operations are competitive, safe and environmentally benign.

IMD provides this industry with a unique concentration of knowledge, facilities and technologies to solve engineering problems related to operations in Canada's ocean environment – from defence and shipping to offshore oil and gas operations.

Key ocean engineering research contributions in 1999-2000 included:

Tug tech improves performance
NRC and Robert Allen Ltd. of Vancouver began exploring the manoeuvring and towing characteristics of escort tugboats – a versatile, new breed of vessel that uses vertical axis propeller technology. The research has produced results that will improve standards and operating procedures of value to Canadian offshore oil and gas operators, as well as providing Robert Allen Ltd. with a new technological and commercial advantage.

Ice-propeller interaction study for better design/performance
Research is under way to determine the forces induced by ice on modern propeller design. This will enable the development of rules for the required strength of propellers used on ships that transit ice. As part of this project, IMD designed and built a novel miniature dynamometer for measuring loads induced by propeller blades on the propeller hub.

Bergy bits lose bite
Continuation of a three-phase research project to study the interaction of bergy bits (small icebergs) and ships will eventually result in ships and offshore platforms designed to better withstand the impact of these marine hazards.

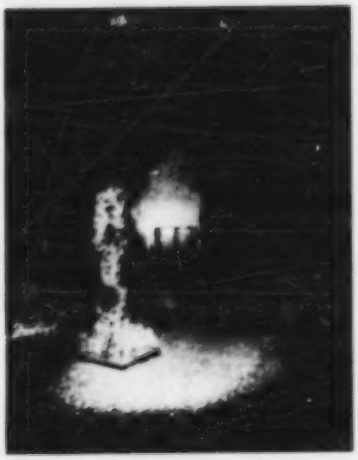
New environmental monitoring vehicle
IMD is collaborating with Memorial University and other academic and industry partners on technologies to develop and use autonomous underwater vehicles (AUVs) for monitoring the offshore environmental impact of pollutants and toxicants from rock cuttings and drilling muds. The project will also result in opportunities for firms to develop, build and operate AUVs.

"IMD's research was instrumental in identifying several critical aspects of our design, for which there was no available published information. This enabled us to assure our clients that our design was correct. This work has been of significant benefit to Robert Allan Ltd.'s stature in the small craft design business world-wide."

Robert Allan
President
Robert Allan Ltd.

Advances in construction

NRC's Institute for Research in Construction (IRC) develops and maintains research competencies and the knowledge base critical to the needs of the Canadian construction industry – one of Canada's largest industries, encompassing some 125,000 companies and 750,000 people. IRC aims to achieve two key goals: wealth generation for economic impact; and, in partnership with the provinces and territorial governments, leadership in advancing a progressive, technically sound building regulatory system receptive to innovation.



IRC's efforts in research, innovation and codes saw significant advances in 1999-2000, including:

Putting the "best" to work in urban renewal
IRC initiated work on a National Guide to Sustainable Municipal Infrastructure, an innovation and best practices guide focused on development of decision making and investment planning tools for municipal infrastructure. The guide will help municipalities across Canada take advantage of the best knowledge and technologies in their infrastructure development and renewal work.

Fire safety comes first
Researchers developed a new compressed air foam technology that uses low water volumes to extinguish fires. Less water means less damage from fire fighting and more protection for people living in areas with short water supply.

Integrated code development
For the first time ever, NRC brought provincial and territorial governments together to discuss building, fire and plumbing codes. This resulted in agreement to integrate the provincial and national code development processes and to move these codes to a new objective-based structure. Smarter, clearer regulations and reduced interprovincial barriers will create opportunities for Canadian businesses to introduce innovative products and systems, and will ensure healthy, safe and accessible Canadian homes and buildings.

Making Canada's homes safe and sound
IRC research improved the acoustic performance and fire resistance of floors in Canadian homes. Research results will be incorporated into the National Building Code of Canada, providing homebuilders with greater choice of building products and designs, and homeowners with improved safety and comfort. The increased design options allow a wider range of materials to be used, leading to fairer competition between manufacturers and greater export opportunities.

Improving classroom environments
Researchers developed new ventilation strategies for portable classrooms, based on the first empirical data available on indoor air quality in portables. This project, in partnership with Natural Resources Canada and the Ottawa Board of Education, will lead to better ventilation systems and reduced energy consumption costs.

STATEMENT OF OPERATIONS BY ORGANIZATION

FOR THE YEAR ENDING MARCH 31, 1999

(Dollars are in thousands)

FY 1998/1999

Organization	Expenditures [1]	Income
Research Institutes	$296 538	$51 273
Industrial Research Assistance Program	126 377	4 898
Scientific and Technical Information	38 445	17 754
Technology Centres	9 028	8 478
Corporate Branches	89 795 [3]	3 863
Total	**$560 183**	**$86 266**

FOR THE YEAR ENDING MARCH 31, 2000

(Dollars are in thousands)

FY 1999/2000

Organization	Expenditures [1]	Income
Research Institutes	$316 397	$60 100
Industrial Research Assistance Program	137 549	21 581
Scientific and Technical Information	42 668	21 578
Technology Centres	9 831	9 398
Corporate Branches	92 103 [3]	5 425
Total	**$598 548**	**$118 082**

1 Expenditures shown above include both appropriation and income based expenditures.

2 Includes amounts received and expended under IRAP Technology Partnerships Canada Pre-Commercialization program (1998-1999, $4.605M; 1999-2000, $20.636M).

3 Expenditures include construction projects for research institutes, managed centrally, and resources for a new Council-wide information system.

NRC INSTITUTES/PROGRAMS

BRI	Biotechnology Research Institute (Montréal)
CISTI	Canada Institute for Scientific and Technical Information (across Canada)
HIA	Herzberg Institute of Astrophysics (Victoria, Penticton)
IAR	Institute for Aerospace Research (Ottawa)
IBD	Institute for Biodiagnostics (Winnipeg)
IBS	Institute for Biological Sciences (Ottawa)
ICPET	Institute for Chemical Process and Environmental Technology (Ottawa)
IIT	Institute for Information Technology (Ottawa)
IMB	Institute for Marine Biosciences (Halifax)
IMD	Institute for Marine Dynamics (St. John's)
IMI	Industrial Materials Institute (Boucherville)
IMS	Institute for Microstructural Sciences (Ottawa)
IMTI	Integrated Manufacturing Technologies Institute (London)
INMS	Institute for National Measurement Standards (Ottawa)
IRAP	Industrial Research Assistance Program (across Canada)
IRC	Institute for Research in Construction (Ottawa)
PBI	Plant Biotechnology Institute (Saskatoon)
SIMS	Steacie Institute for Molecular Sciences (Ottawa)
IC	NRC Innovation Centre (Vancouver)

Technology Centres

CHC	Canadian Hydraulics Centre (Ottawa)
CSTT	Centre for Surface Transportation Technology (Ottawa, Vancouver)
TTC	Thermal Technology Centre (Ottawa)

BRI

Biotechnology Research Institute (Montréal, Québec)

Improving the health of Canadians and their environment

BRI research programs are closely linked to the changing needs of pharmaceutical and natural resources industries. Established 11 years ago, BRI is the largest laboratory site in Canada dedicated to biotechnology R&D. Located in the centre of Montréal's biopharmaceutical and environmental clusters, BRI is uniquely positioned to promote, assist and perform research closely linked to the needs of industry.

As part of NRC's Biotechnology Group, BRI scientists work in three major areas: pharmaceutical biotechnology, environmental biotechnology and bioprocess.

The Pharmaceutical Biotechnology sector applies knowledge gained from molecular biology, genetics, protein chemistry and bioinformatics research to create new strategies and therapeutics to treat cancer and infectious diseases.

The Environmental Biotechnology sector develops biologically-based processes centred on pollution prevention and control, pollutant identification and behaviour, technology and process development, and monitoring and ecotoxicological risk evaluation. This sector also researches green technologies and sustainable development; for example, how to manufacture non-polluting products, reuse organic wastes and turn wastes into value-added products.

The Bioprocess sector tests and optimizes pre-production microbial and mammalian cell culture processes. Scientific and engineering staff design equipment and conduct molecular biology research, primarily for industrial clientele.

BRI is also involved in two major Centres: the Montréal Centre for Excellence in Environmental Site Remediation and the National Joint Centre for Structural Biology.

Research to improve groundwater
With industry partners, including Sanexen Environmental Services, BRI developed a biosystem capable of degrading TCE, a carcinogenic compound found as a common contaminant of groundwater and derived from solvents used in industry, particularly dry-cleaning. With further development, the system will improve groundwater quality worldwide and return major drinking water reservoirs to use.

Biosensor tests effluents and influents
BRI researchers, in partnership with a pulp and paper company, are developing a biosensor to test effluents and influents online. Industry can use online testing systems to rapidly detect and control toxics in their effluents and municipalities can monitor their waste water treatment plants.

BRI's Bioprocess facility: testing and optimizing pre-production microbial and mammalian cell culture processes.

CISTI

Canada Institute for Scientific and Technical Information (Ottawa, Ontario)

Information for the new economy

Canadians access the information resources of CISTI and the world through the institute's Web-based catalogue and state-of-the-art document delivery service.

CISTI is North America's largest, most comprehensive provider of scientific, technical and medical (STM) information, as well as Canada's leading publisher of scientific journals and books. As the global economy evolves from resource to knowledge-based, CISTI is increasingly considered a key component of Canada's S&T information infrastructure.

Canadians access the information resources of CISTI and the world through CISTI's Web-based catalogue and state-of-the-art document delivery service. Fast turnaround times and electronic document delivery ensure that Canadians have access to the STM information they need when they need it. CISTI resources benefit researchers, innovators, students, librarians and medical workers in industry, universities, government, hospitals and libraries across Canada and throughout the world.

A national network of NRC information centres, staffed by highly trained specialists, brings vital information resources and expertise to local innovation communities. These centres help researchers and innovators in fields of strategic importance, including biotechnology, biosciences, molecular sciences, astrophysics and specific industry sectors.

CISTI's publishing program, NRC Research Press, offers scientists and engineers 14 international, peer-reviewed journals and a growing list of monographs and conference proceedings.

CISTI resources

- 50,000 scientific journals of which 12,750 are current
- 3,250 electronic journals
- 591,360 monograph titles
- 180,489 conference titles
- technical reports
- NRC Research Press
- Ten NRC Information Centres across Canada

CISTI 1999-2000 highlights

- CISTI opened a new NRC Information Centre in Vancouver to serve the information needs of the NRC Innovation Centre as well as the IRAP offices and scientific communities in B.C. and the Yukon
- Technology Watch Partnership agreements were signed with IRAP partners in B.C. (Canadian Institute for Marketing Intelligence) and Newfoundland (C-Core) to deliver information research services to small companies
- The Institute introduced online full-text search capabilities for the NRC Research Press electronic journals
- The IntelliDoc document delivery system was improved to provide better quality images, more reliable electronic delivery and improved information on order status.

HIA

Herzberg Institute of Astrophysics
(Victoria and Penticton, British Columbia)

NRC's gateway to the stars

HIA operates all astronomical observatories established by the Government of Canada and ensures the Canadian scientific community can access these facilities. The Institute is responsible for the Dominion Astrophysical Observatory (DAO) in Victoria, B.C., the Dominion Radio Astrophysical Observatory (DRAO) in Penticton, B.C. and the Canadian Astronomy Data Centre in Victoria, B.C. The Centre receives data from national and international telescopes, including, with support from the Canadian Space Agency, the Hubble Space Telescope.

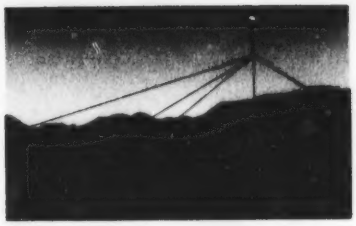
Through HIA, NRC is an international partner in the Hawaii-based 3.6-m Canada-France-Hawaii optical Telescope (CFHT) and the 15-m James Clerk Maxwell Telescope (JCMT) for short-wavelength radio emission. HIA is also an international partner in the Gemini twin 8-m optical telescopes, one in Hawaii, which began operations in 2000, and the other in Chile, which will be completed in 2001. These collaborations heavily leverage Canada's investment in astrophysics, providing researchers with new opportunities and positioning Canada as a major player in international astronomy.

HIA is known worldwide for its astrophysics research, as well as for its development of innovative technological instruments and user-oriented software, including:

- Optical design and coating procedures
- Optical and infrared detector technology
- Multi-object spectroscopy
- Adaptive optics
- Data processing, archiving, and data mining
- Antenna design
- Signal processing
- Sub-millimetre instrumentation
- Phase monitoring for radio interferometry

HIA works closely with Canada's academic astronomy community and a growing number of industrial partners to generate economic benefits from the technologies and software it creates. HIA also helps train students in astronomy and engineering, and promotes public outreach.

Telescopes and satellites
Key highlights include commissioning of the Gemini North telescope in Hawaii; delivering major components of the first Gemini Multi-Object Spectrograph to partners in the United Kingdom; and helping ComDev International for the orbital check-out of the Canadian Fine-Error Sensor on NASA's successful Far Ultraviolet Spectroscopic Explorer Satellite.



SPACE APPLICATIONS ON EARTH

HIA research into the development of the Large Adaptive Reflector (LAR) for radio telescopes promises to reduce the cost of very large reflector antennas compared to conventional technologies. The LAR also could have applications in deep space tracking, and spin-off technologies for tethered aerostats and control systems for flexible structures.

IAR

Institute for Aerospace Research (Ottawa, Ontario)

Aerospace research attains new heights

"We came to NRC for its expertise and facilities. You can't find facilities of this calibre anywhere else in Canada. Canada needs to retain such expertise and this project is helping build it."

Captain James Sylvain Graveline
Department of National Defence

IAR supports the needs of the Canadian aerospace community and maintains strong ties within the international aerospace sector. The Institute promotes and assists research and development in aircraft and related vehicle design, manufacture, performance, use and safety. IAR interacts extensively with a number of industry sectors – from manufacturing and air carriers to repair and overhaul companies – to ensure its major research programs and activities stay aligned with industry's emerging needs. IAR explores essential industry research competencies and knowledge at its three laboratories.

The Aerodynamics laboratory researches the aerodynamics and flight dynamics of aircraft, and the aerodynamics of surface vehicles and ground-based structures. The Flight Research laboratory studies flight mechanics and avionics, and performs complex airborne research experiments. The Structures, Materials and Propulsion laboratory supports the Canadian aerospace community in areas affecting the design, strength, durability, structural integrity and performance of aircraft, gas turbine engines and space structures.

IAR provides the major national facilities used to design, develop and certify Canadian aerospace products, and the core competencies to maintain and develop the facilities and to interpret the data they supply. The Institute's facilities include seven wind tunnels, air compressor/exhauster facilities, engine test cells, a full-scale structural fatigue rig, aeroacoustics chambers, a Flight Data Recorder Playback Centre and a fleet of research aircraft.

Improving weather and climate forecasting
Under the Global Energy and Water Cycle Experiment, researchers developed airborne methods to investigate the exchange of energy and trace gases between the earth's surface and the atmospheric boundary layer. The results improved numerical models that predict climate change, leading to better weather and climate change forecasting.

Extending aircraft life expectancy
Wind tunnel tests and supporting modelling and simulation using computational fluid dynamics methods were all part of IAR testing of the Aurora Long Range Patrol Aircraft. The objective was to determine the feasibility of extending the safe life of the aircraft to 2025 – years longer than originally anticipated. These results indicate taxpayers will save millions of dollars because the aircraft will operate safely for much longer than anticipated. Additionally, it will provide continued repair and overhaul business for the Halifax company that currently maintains the aircraft. The Aurora testing models will now be used to test new propeller designs.

IBD

Institute for Biodiagnostics (Winnipeg, Manitoba)

Improving Canadian patient care and medical diagnostics

IBD conducts research and develops leading-edge instrument-based, non-invasive medical diagnostic technologies. The Institute performs its research in partnership with medical schools, universities, other research organizations and industry. Partnerships help IBD improve growth and diversification opportunities for Canadian companies and fuel the Institute's ability to more effectively diagnose, and monitor treatment for, diseases that significantly affect Canadians.

IBD has four core research groups:

- The Biosystems Group uses non-invasive investigative techniques, such as magnetic resonance (MR) and infrared (IR) spectroscopy, and is primarily focused on cancer, heart disease and stroke
- The Informatics Group develops and adapts methods to analyze and monitor complex biomedical data and helps bring the resulting software products to market
- The Magnetic Resonance Technology Group develops magnetic resonance techniques and instruments to diagnose human disease, and creates protocols to apply these techniques to solve medical and biological problems
- The Spectroscopy Group uses optical methods, including the development of infrared imaging, to pursue goals similar to those of the MRT Group.

IBD-designed intraoperative magnetic resonance imager (MRI) allows neurosurgeons to monitor progress during surgery.

Evident opens new paths for epilepsy research

In just three short minutes, IBD's pioneering image analysis software, Evident, changed forever Sweden Karolinksa Institute researchers' views on epilepsy and brain activity.

Knowing that their patient experienced seizures nearly every 10 minutes, researchers used a 1.5 Tesla magnetic resonance (MR) imager and IBD's Evident software to track the patient's brain activity. They recorded a 10-minute period that included a three-minute seizure. The results told a startling story – two minutes before the seizure, the patient's brain behaviour began to change. IBD's software also identified new locations of brain activity. These discoveries open a new set of possibilities for epilepsy research.

The Karolinksa Institute is a project collaborator, and one of eight beta test sites in the world to test this groundbreaking identification software. The software resulted from ongoing work aimed at developing more powerful means to analyze the outcome of functional magnetic resonance imaging.

Evident is based on unsupervised pattern recognition strategy and extends image analysis far beyond current method limitations. Because Evident requires no specific model for the activating protocol, it can detect unexpected or novel responses.

Drugs to match specific pain

Pre-clinical studies of pain using advanced functional MRI techniques are allowing the mapping of pain centres in the brain, leading to the development of analgesic compounds specifically designed to deal with various types of pain.

IBS Institute for Biological Sciences (Ottawa, Ontario)

Easing the affects of debilitating diseases

"This collaboration, with its mix of basic targeted research, coupled with the applied sequential development program is a perfect match. IBS has provided Alviva with the means to get first-class scientific support and speed up its developmental process."

Dr. Alan Boulton
President and Chief Scientific Officer
Alviva Biopharmaceutical Inc.

The Institute for Biological Sciences (IBS) conducts innovative research in neurobiology and immunochemistry of importance to the health and pharmaceutical sectors. IBS carries out its research programs with partners in industry, university and hospital settings and with other R&D organizations.

IBS research focuses on:

- Neuro-degenerative diseases, such as stroke, Alzheimer's, Parkinson's and epilepsy
- Osteoporosis
- Vaccines and immunotherapies against infectious diseases
- Therapeutic cancer vaccines.

IBS encompasses two major research programs. The Cell Biology program develops applications related to therapies for neuro-degenerative disorders through its three research groups, Apoptosis, Cellular Neurobiology, and Receptors and Ion Channels. The Immunochemistry program conducts molecular-level research through a multidisciplinary team, which leads to the development of novel vaccines and immunotherapeutics. These are pursued through the Bioanalysis, Carbohydrate-Protein Systems, Glycoconjugates and Tumor Immunology, Infection and Immunity, Molecular Pathogenesis, and Pathogen Genomics research groups.

IBS has a strong track record for transferring technology and knowledge to multi-national, small and medium-size Canadian firms. IBS is also closely involved with the development and activities of three Canadian Centres of Excellence Networks: Bacterial Diseases, Arthritis and Stroke.

IBS/Alviva collaboration leads to promising new drug

IBS provided Alviva Biopharmaceutical Inc., a Saskatchewan-based drug company, with the complementary science it needed to strengthen its drug development capacity without creating a significant drain on the company's limited resources. IBS believes that the knowledge Alviva gained from this collaboration will help to identify lead drugs for Alzheimer's, stroke, Huntingdon's, Amyotrophic Lateral Sclerosis (ALS), and cancer.

ICPET

Institute for Chemical Process and Environmental Technology (Ottawa, Ontario)

Supporting Industry – Protecting the environment – through technology

ICPET develops chemical technologies to help Canadian industry improve the commercial viability and competitiveness of their products, reduce costs, manage their environmental performance and gain efficiency in their process operations.

The Institute's core research competencies are:

- Functional materials: new polymers, chemically-based sensors and high-performance energy materials for batteries and fuel cells
- Cleaner production technologies: electrochemical and interfacial technologies for manufacturing applications involving chemical use and recycling, and waste treatment
- Advanced diagnostics: for measuring, analyzing and assessing the properties and performance of materials or processes
- Separation processes: membrane-based technologies for industrial processes such as waste water treatment, agri-food processing, pulp and paper/mining effluent reduction, and petrochemical gas and vapour treatment
- Simulation and design: with applications to air quality modelling, computational fluid dynamics, modelling of reactive flows such as combustion, chemical process design/simulation/economics, industrial spray systems, and environmental management

ICPET works in several fields that are essential to helping industry improve environmental performance and sustainability. These include combustion technology; electro-chemical treatment of organic and inorganic contaminants; air pollution monitoring and control; separation technology; chemical systems analysis; energy materials; and assessing and improving the sustainable/environmental performance of technology designs.

ICPET continues to be involved in frontier research that supports environmental and industry agendas, which includes:

- Using ceramics to develop solid oxide fuel cells through research into lower temperature electrolytes, cathode materials, anode materials and fabrication processes
- Testing functional thin films and chemical sensors with applications from industrial manufacturing and control, to environmental monitoring – a potential commercial market estimated at more than $5 billion annually
- Studying energy storage to develop next-generation cathode, anode and electrolyte materials and manufacturing processes for rechargeable lithium ion batteries
- Developing electrochemical process technologies used to treat organic and inorganic contaminants in waste water (e.g. paper mills, gold mines) and in high purity processes (e.g. plating solutions).

NRC's Institute for Chemical Process and Environmental Technology (ICPET) is pioneering research and development on materials for energy storage and generation applications. Research has focused on advanced lithium battery technology.

NEW OFFICE FOCUSES ON THE ENVIRONMENT

ICPET recently established an Environmental Management Office (EMO) to facilitate NRC's response to sustainable development, and to link this actively to the competitiveness and environmental agendas of both Canadian industry and the Federal Government.

The office has particularly emphasized support of activities responding to climate change challenges. The EMO has also undertaken a "user-friendly" integration of environmental impact analysis tools for use in product, process and business/operations optimization.

IIT

Institute for Information Technology (Ottawa, Ontario)

Strengthening Canada's leadership in information and telecommunications

Research in IIT's Network Computing group centres around the study of highly-connected computing and communications systems, with a goal of making these systems more flexible, more secure, easier to manage and easier to use.

IIT creates and commercializes new software and systems technology, strengthens software engineering practices in the private sector, and communicates, educates and consults to help Canada prosper in the information age and knowledge economy. With information technology permeating all sectors of the economy, IIT is playing an increasing role in sectors other than information technology, including manufacturing, biotechnology and electronic business.

IIT collaborates in information and telecommunications technologies with business, universities, and government agencies, as a key player to strengthen this sector. IIT helps industries across Canada improve their competitiveness in information technology, develop innovative solutions to industry problems, and identify new business opportunities.

IIT's five research groups include:

- Interactive information: focuses on creating new models to communicate information, tools to help acquire and distribute knowledge, and tools to find, organize, summarize and navigate through information
- Software engineering: devises tools and techniques to help Canadian software companies improve both products and development processes
- Integrated reasoning: concentrates on automating and improving aspects of corporate decision-making, helping companies use innovative information technologies to enhance their business objectives
- Network computing: researches highly connected computing and communications systems
- Visual information technology: leads the way for innovation in 3D imaging, 3D information management and virtualized reality, with applications in manufacturing, heritage, anthropometry, medicine, road inspection, space and entertainment.

The Institute also supports Canada's high performance computing community, managing the C3.ca Coordinating Office.

Along with the Institute for Microstructural Sciences, IIT operates an Industry Partnership Facility (IPF), which helps small and medium-size businesses exploit emerging technologies by providing a supportive working environment and access to NRC expertise.

"Our solution allows individuals to receive the information they want, when and where they want it, regardless of the communications device involved."

Dr. Abu-Hakima
President and CEO
AmikaNow! Corporation

AmikaNow! highlights the way to success

It is estimated that there will be a billion wireless Internet devices by 2003. In response to an urgent need for a digital e-mail clerk, IIT spin-off AmikaNow! developed a service that monitors multiple e-mail accounts and delivers condensed, relevant, easy-to-read e-mail highlights to a small, wireless display screen.

The software is largely based on artificial intelligence research conducted at NRC. The company is currently holding partnership discussions with more than 75 global firms interested in either bundling or integrating the technology's components into their product or service.

IMB

Institute for Marine Biosciences (Halifax, Nova Scotia)

Aquaculture and genomics for Canadians

IMB's targeted, innovative and strategic biotechnology research in aquaculture and genomics focuses on diversifying Canada's aquaculture industry and on developing genomics technologies.

The Institute's aquaculture research is primarily concentrated on: fish and shellfish health, including nutrition; developing alternative species of fish, shellfish and seaweed for aquaculture; and producing standards and reference materials used to ensure seafood safety.

The genetics research program targets the development of platform technologies in genomics – high throughput DNA sequencing, unique bioinformatics software development and proteomics (protein sequence analysis) – that apply to aquaculture, and other areas relevant to Canada.

On behalf of NRC, IMB operates and manages the Canadian Bioinformatics Resource (CBR), a national facility dedicated to providing Canadian researchers with convenient, effective access to biotechnology-related databases and bioinformatics software tools. CBR will be a key component of the Canadian Heart Network, a Network Centre of Excellence. IMB is working with the network to create a workable model to ensure that needed infrastructure is provided in the most effective way possible. IMB is also a member of AquaNet, the Network Centre of Excellence dedicated to aquaculture development. CBR now also has several associate member nodes in other government departments and at universities.

IMB significantly influences innovation and economic growth in the region through its interactions with clients in private, academic, and government sectors. For example, the Institute has collaborated with:

- Scotian Halibut, to help it establish the most significant halibut cultivation facility in Canada
- Microtek International Ltd., which specializes in aquaculture therapeutics and vaccines
- ShurGain, for fish feed
- Jellett Biotek Ltd. to develop test kits for detecting marine toxins in shellfish
- Xenon Genetics Inc. to identify a gene that regulates cholesterol levels in the body
- Kinetek Pharmaceuticals Inc. on the development of proprietary bioinformatics tools that will enable them to identify drug targets
- MDS-SCIEX to develop miniaturized separation systems for high-sensitivity protein identification using mass spectrometers.

IMB works in collaboration with Connors Bros. Ltd. to develop techniques for commercial-scale haddock production.

IMB RESEARCH STATION HATCHES NOVEL IDEAS FOR AQUACULTURE

IMB's marine aquaculture research station is a proven pilot-scale finfish hatchery and a respected facility for research on fish nutrition and feed technology, and for studies of marine animal development. Successes include:

- **Improving larval rearing techniques and hatchery production technology used for new marine fish species aquaculture, which will foster diversification of the aquaculture industry in the Atlantic provinces**
- **Developing a novel microalgal photobioreactor capable of mass-producing high-quality algal biomass at reduced costs for finfish and shellfish hatcheries and producing algal biomass for toxin standards and bioactives research.**

IMD

Institute for Marine Dynamics (St. John's, Newfoundland)

Responding to marine challenges

The Terra Nova oil production vessel undergoes seakeeping experiments in IMD's Offshore Engineering Basin.

IMD's mission is to provide innovative solutions and engineering expertise related to ocean technology. In collaboration with industry and university partners, the Institute pursues research programs in ship technology and offshore engineering, focusing on such areas as ship and underwater vehicle dynamics, ice effects on marine systems, mooring and towed body simulation, wave-current interaction, and wave impact analysis. IMD research supports a wide range of Canadian and international projects, from high-performance naval vessel operations to offshore oil and gas exploration.

The Institute's facilities include the world's longest ice tank (90 metres), an offshore engineering basin, and a 200-metre towing tank. IMD's specialized equipment includes a marine dynamic test facility to evaluate vessels in six degrees of freedom of motion, a planar motion mechanism to study manoeuvring characteristics, a yacht dynamometer and a cavitation tunnel.

IMD combines expertise and world-class facilities to address the needs of large multi-national companies, small ventures and consultants. It brings an international reputation for research excellence to its work with offshore firms and research organizations. The Institute acts as a Canadian conduit for international ocean engineering technology. Long-term collaborative research projects invest in development of the knowledge that will permit Canadian industry to compete in the 21st century's global marketplace.

IMD has also commercially launched Oceanic Consulting Corporation, in collaboration with Memorial University and Marineering Ltd. To date, this company has completed 14 national/international client projects in IMD facilities.

IMD tackles ocean challenges

- IMD researchers continue to study ship manoeuvring and wave-induced loads in an effort to help reduce increasing ship losses caused by structural failure and to increase marine transportation safety by more accurately predicting ship trajectories
- Researchers are also studying the effects of ice on marine systems to determine the safest, most economically feasible technical solution for projects such as Grand Banks oil production. The high density of icebergs in this region increases the risk of ship collision and the potential for oil spills
- In offshore technology research, IMD investigates the positioning and mooring of floating production structures to assess the potential for new, dynamic positioning strategies. The need to develop such strategies continues to intensify with the increased use of floating production platforms in offshore Eastern Canada and around the world.

IMI Industrial Materials Institute (Boucherville, Québec)

Working with industry to improve materials processing

IMI promotes the growth and competitiveness of Canadian industry through research and development activities related to materials processing technologies. IMI works across a broad spectrum of industrial sectors, including aerospace, automotive, advanced materials, steel, plastic, food and beverage packaging, energy, information technologies, raw materials production, instrumentation, and finished-product manufacturing.

IMI offers multidisciplinary expertise focused on the next generation of technologies and high-performance systems necessary to produce new materials and manufacture the products that consumers in the 21st century will demand. R&D efforts are centred on two fields of activities:

- Design of Materials Processing through the understanding of science principles to optimize the formulation and the behaviour of materials in the process-structure-performance continuum
- Virtual Technologies and Intelligent Control through 3D modelling, simulation, visualization and real-time sensing, high-performance computational methods and information processing.

The Institute has received international recognition for its work with scientific collaborators as well as for its active involvement in technology transfer to industry.

Models mould more resistant auto parts

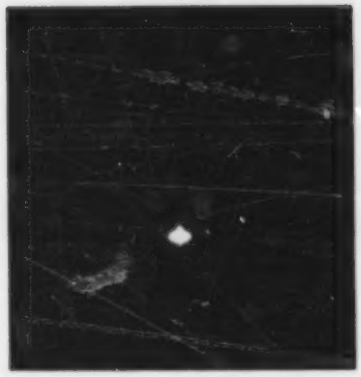
Working with Canmet, IMI developed numeric models to mould light metals in semi-solid state, which resulted in the production of more resistant automobile parts. Through the simulation tools developed, the team gained a better understanding of the processes involved. This research is opening doors for the development of a new procedure to enable lighter parts production.

Environmentally-friendly composite materials

IMI has reached an important milestone in a multi-partner project aimed at producing high-quality composite material parts. Using a new class of thermoplastic composites (rather than the conventional thermoset materials) this new industrial process eliminates the use of styrene in the production chain. The emission of styrene is a major environmental hazard for the composite materials industry. This new process has already been adopted by some of the project's industrial partners. These partners include: Bombardier, Bauer, ADS Composites Group, Camoplast, Armtex, MAAX, René Matériaux Composites, Protectolite, Baycomp and FRE Composites.

Other 1999-2000 partnership highlights

- In collaboration with Novoplas, IMI has perfected materials based on recycled plastics. These materials have been eagerly adopted by the automotive industry
- IMI researchers partnered with Columbia Injection Moulding and Honeywell International to develop a simulation software for injection moulding of metallic powders.



IMI spinoff company PharmaLaser uses laser-induced plasma spectroscopy technology for pharmaceutical product quality control.

"There is no doubt that IMI's pertinent, multi-disciplinary expertise allowed Novoplas to establish itself and quickly gain credibility in a very competitive market. To this day, IMI remains a strategic partner and an essential asset for the growth of our enterprise."

Florin Tofan
Vice-President, Technology
Groupe Lavergne/Novoplas

IMS

Institute for Microstructural Sciences (Ottawa, Ontario)

Leading the information technology revolution

New black layer technology
Black layer technology developed at IMS is providing Luxell Technologies with unique advantages for its flat panel displays, such as those used on the A-340 Airbus passenger aircraft.

IMS collaborates with Canadian industry to provide national leadership in developing the strategic base for information technology – creating the enabling technologies needed for future hardware used to acquire, process, transmit, store and display information. The Institute works with the leading-edge technologies that will drive the information revolution during the next decade.

IMS partners with industry to exploit the technological advances that result from research and to reduce the risk to industry by investing in those alternative technologies, which if achieved, would represent a paradigm shift.

The Institute's core competencies include: photonic device design and fabrication, semiconductor process development (organic and inorganic), thin film technology, nanotechnology, and acoustics.

IMS applies its expertise in novel materials and components to solve problems posed by the need for advanced hardware through both national and international initiatives.

IMS looks ahead to solve technology challenge
IMS helped partner Mitel Semiconductor develop a prototype semiconductor that could double data transmission capacity more cheaply and effectively. The new semiconductor increases the number of light channels on a glass fibre from 16 to 40. The product uses Echelle gratings, which bounce light signals off a silicon chip structure to create new channels. These gratings, known since the late 19th century, have been the subject of recent research interest in the U.S., Canada, Sweden and Japan, but NRC and Mitel were the first to discover how to make the technology work at high channel counts.

"Mitel Semiconductor is currently engaged with NRC's Institute for Microstructural Sciences in a collaborative project encompassing the research and development of photonic devices. The collaboration has just entered its second year and is proceeding ahead of schedule. NRC's outstanding level of expertise and cooperative spirit made this possible. The truly excellent working relationship that has formed is facilitating very rapid and fruitful progress."

Dr. John Miller
Director, Microelectronics R&D
Mitel Semiconductor

IMTI

Integrated Manufacturing Technologies Institute (London, Ontario)

Breaking new ground for Canadian industry

IMTI plays a major role in promoting the international competitiveness of Canadian manufacturers by focusing its research and development on leading-edge technologies for discrete product and equipment manufacturing at the design and production levels. The Institute works with manufacturers and other technology providers to address manufacturing challenges through joint research projects.

IMTI conducts research in concurrent engineering, distributed manufacturing, modelling and visualization, material addition processes, precision manufacturing processes and shape transfer processes. IMTI's research, conducted with collaborators in key industry sectors such as aerospace, automotive, tooling, medical devices and electronics, is breaking new ground for Canadian industry.

As just one example, IMTI developed a precise laser cutting and material removal process using very high power density, short pulse duration lasers to produce extremely fine features in virtually any material. In the short term, the focus is on medical and biological instrumentation and integrated sensors. These new processes will eventually lead to the development of nano-fabrication processes in the automotive, aerospace, medical and biotechnology sectors.

Collaborative R&D in IMTI's VETC theatre: a real crane cab is put through its paces in a virtual reality environment.

Virtual reality saves costly mistakes

IMTI researchers have created a virtual environment design and simulation centre known as the Virtual Environment Technologies Centre (VETC). Virtual environment technologies allow anyone – including auto makers, architects, surgeons, designers, manufacturers, planners and builders – to test ideas, plans, projects and techniques faster, more accurately and more comprehensively than ever before and save millions, possibly billions, of dollars.

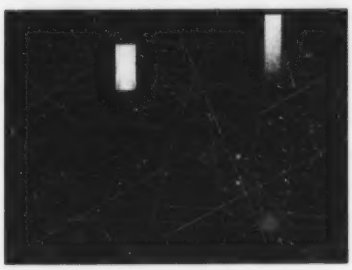
In the VETC, ideas leap from paper into 'real-world' 3D form on a variety of 3D displays. For instance, the design rooms have a screen the size of a billiard table. The virtual theatre can display a prototype automobile in full size to a group of 30 reviewers. In the cave-like environment, designers can step inside their virtual finished product, reach into dark corners, explore the surrounding environment and prevent costly errors before they occur. Imagine:

- Automotive manufacturers bypassing the prototype stage when designing engines for cars and trucks, for important gains such as improved time-to-market, superior product quality and paired-down design costs
- A surgeon's hands safely practicing the minuscule movements of a challenging technique inside the heart or brain of a virtual human being
- Virtual environment technologies being used for training systems; for example, to train crane operators.

INMS

Institute for National Measurement Standards (Ottawa, Ontario)

Ensuring Canada measures up



The Monte Carlo Dose ca'culation software, developed at INMS, wil. improve the accuracy and the speed of radiation treatment planning for cancer patients. Doctors can plan radiation treatment more quickly and better determine the precise dose distribution, so that the dose to the tumour can be maximized while the dose to healthy tissue is minimized.

Measurement standards are one of the foundations of a modern economy. Essential to industry growth and international competitiveness, these standards assure the validity, accuracy and traceability of measurements made throughout the economy. This assurance occurs through documented calibration chains that relate measurements to the high-accuracy national measurement standards maintained by each country's national metrology institute.

As Canada's national metrology institute, the Institute for National Measurement Standards is a fundamental enabling element in the Canadian Government infrastructure. Its role is to support Canadian industry and the Canadian public by:

- Facilitating Canada's global trade and global co-manufacturing by providing the necessary national primary measurement standards and calibration-related services, and by ensuring that those measurement standards and services are internationally recognized and internationally competitive, thereby contributing to the reduction of technical barriers to trade
- Strengthening the competitiveness of Canadian companies by facilitating, through a viable national measurement system, the traceability of their measurements to those national measurement standards and services
- Ensuring that Canadian companies exploiting emerging advanced technologies are supported through the timely development of appropriate new measurement standards and services
- Addressing health and environmental issues through chemical metrology services that create appropriate measurement standards and certified reference materials.

INMS researchers tackle cancer treatment

INMS conducts R&D to measure ionizing radiation and provides services, such as calibrations, consultation and training to clients working in cancer radiotherapy, radiation protection, international standards and industrial radiation. The program is developing Monte Carlo techniques to simulate electron and photon transport in materials, and dosimetry protocols for use in cancer radiotherapy clinics.

In cancer treatment with radiation, it is critically important to accurately measure and deliver the dose. INMS is playing a leading role in a worldwide change from clinical dosimetry based on exposure standards to an approach based on absorbed dose standards. INMS developed state-of-the-art primary standards of absorbed dose and its researchers were instrumental in developing a new clinical protocol for applying these standards formally approved by the American Association of Physicists in Medicine. Once implemented, Canada and the United States will routinely apply these advanced standards to treat cancer in about 600,000 patients a year and to improve clinical efficiency and the accuracy of the delivered dose.

IRAP

Industrial Research Assistance Program (across Canada)

Building capacity in the Canadian innovation system

IRAP's mission is to connect Canada's innovative small and medium-size enterprises (SMEs) with the information, resources and financial support they need to turn good ideas into commercially viable products and services. For more than 50 years, IRAP has helped SMEs develop and adopt innovative technologies that yield new products, create high-quality jobs and increase Canadian industry's competitiveness. IRAP support stimulates R&D and builds technical knowledge and expertise in Canadian firms.

Central to IRAP's success is its backbone of 262 Industrial Technology Advisors (ITAs) who work with some 12,000 firms annually in all regions of the country and in all industrial sectors. IRAP offers direct access to the latest technological advances, expertise, facilities and resources, and cost-shared financing of innovative technical projects. IRAP also helps clients access expertise in the business end of innovation, such as marketing, financing and production, through the Canadian Technology Network (CTN).

CTN links innovation-related resources and provides path-finding services to SMEs through its 1,000-strong membership. CTN's consultation network includes private sector firms, many levels of government and a number of industry associations.

From small beginnings

Mathis Instruments Ltd. of Fredericton, New Brunswick conducts research and development, manufactures, distributes and markets the latest thermal measurement instruments used to evaluate materials and end-products in a non-destructive manner. It supplies the appliance, automotive, aerospace and electronics industries.

IRAP made a small investment of $60,000 in assistance to conduct pre-market readiness engineering of the Mathis TC Probe device for specific industries. That small investment was instrumental in leveraging venture capital for Mathis' commercialization activities. Investments from the Business Development Bank of Canada and Canadian Science and Technology Growth Fund totalled $1.5 million. Mathis Instruments Ltd. received a prestigious R&D 100 Award and the 2000 Planet Entrepreneur Award, which recognizes the excellence of Atlantic Canada's young entrepreneurs.

Domestic waste water treatment – the natural way

The Abydoz Environmental Company in Newfoundland is installing a test system that uses an engineered wetland to filter and break down waste matter before it enters the ground surface water system. The treatment system needs no mechanical support for normal operations, and the treatment plants are self-sustaining. IRAP assisted Abydoz with further study of this technology (acquired from a German company) and with financial assistance for its first municipal installation. Initially, the test system will take waste from 30 homes in the area. If the process proves functional, it will be expanded to include all 120 homes in the area and to replace the area's current system.

Vansco Electronics Ltd. is Canada's premier developer and manufacturer of electronic instrumentation, monitors, controllers and wire harness assemblies for sale to manufacturers of on-and-off road heavy equipment. With IRAP support, the company has created the Vansco Modular Multiplexed (VMM) System, an initiative that has the company on the brink of capturing a major share of the huge worldwide market for modular electronic control systems for buses.

IRC

Institute for Research in Construction (Ottawa, Ontario)

Safe, durable, comfortable – at home, at work, on the road

Taking the forms down at the CCHT InfoCentre after the first-ever pour of self-leveling concrete for residential basements in Canada.

IRC partners with industry to improve the safety, durability and comfort of Canadian homes, offices and other work environments, and to extend the service life and performance of municipal infrastructure, such as roads, bridges and water systems. Key program areas include:

- Indoor environments: improving acoustics, thermal comfort, lighting use and air quality in all types of buildings
- Building envelope and structure: optimizing envelope performance and structural safety of both new and rehabilitated buildings
- Urban infrastructure rehabilitation: improving technologies used to design, construct, operate and maintain buried services and surface structures
- Fire risk management: providing sophisticated tools to assess the risks and costs of fire safety options for buildings, and developing economical and effective methods of fire resistance, detection and suppression
- A national evaluation service that determines how suitable innovative construction products and technologies are for their intended use
- A national code centre that supports the development of the National Building Code and other national model codes on which construction regulation across Canada is based
- The production of practical technical information that IRC disseminates to construction practitioners.

Lighting lab goes high tech
IRC, in collaboration with PERD and Public Works and Government Services Canada, brought online a new national Lighting Controls Development Laboratory that industry can use to develop and test new lighting control technologies.

Researchers patent new super-plasticizers
Researchers developed a new concrete super-plasticizer, patented on behalf of NRC by Natural Resources Canada. The technology allows for more durable concretes, opens new manufacturing opportunities and is cheaper than current products. This will lead to wider use of super-plasticisers and will likely generate a new spin-off company from NRC.

Research leads to better water pipes
Researchers conducted a "Failure Analysis of Cast Iron Water Pipes" which revealed the reasons water mains and pipes fail, including metallurgical factors, casting practices, external forces and corrosion. In turn, this research will lead to the development of best practices for investigating pipe failure, which is expected to lower repair costs for municipalities. Solutions like this may, in time, reduce the number of emergency repairs and repair failures, and lower risks of water quality problems.

PBI Plant Biotechnology Institute (Saskatoon, Saskatchewan)

Better crops – better markets for Canada

PBI is a major centre for plant biotechnology research in Canada, with expertise in transformation, promoters, gene expression, genomics, metabolic pathways, DNA sequencing and biochemistry. PBI probes the areas of plant biotechnology that will enhance Canada's position in the highly competitive global market of crops and crop products and then transfers the new technologies and resulting products to Canadian industry.

The Institute is a world leader in the genetic engineering of wheat and in modifying Brassica seed oil.

PBI's main research areas include: Brassica technology; cereal biotechnology; legume biotechnology; gene expression; growth regulation; promoter technology; and seed oil modification. Transgenic plant and DNA technologies help the Institute develop novel systems to analyze and manipulate genes, leading to state-of-the-art technologies and crop development.

PBI's continuing work in plant genomics and improved understanding of plant growth and development set the stage for the introduction of a host of new products with unlimited potential. Products resulting from this research, such as insect-resistant and herbicide-tolerant crops, are already available in the marketplace.

PBI's Cell Technologies Program develops technology that produces genetically-pure plants from microspores and creates methods to insert foreign genes into plant cells and cause cellular change. Developing genetically pure plants from microspores is a well-established basic plant-breeding tool that accelerates the development of valuable plant varieties.

Through PBI's Gene Expression Program discoveries are made about the molecular processes that regulate cell growth and about the molecular biology of plant development. Basic aspects of plant cell growth, division and development are fundamental in understanding the cellular processes that define the utility, value and performance of all crop plants.

New wheat for the world

In response to growing demand for wheat with improved growth properties, PBI researchers collaborated with the Saskatchewan Wheat Pool to successfully employ haploid technology for crop improvement, from cultured pollen to a new strain of wheat.

The result was a hard red spring wheat that the partners registered as McKenzie. The new wheat is an early maturing, high-yielding variety with good protein content and a 12-15 percent yield advantage over Neepawa, an eastern high-yield variety. McKenzie is also sturdier, more compact and resists disease well. Introductory sales of Mckenzie seed volumes have exceeded the amount needed to plant more than 500,000 acres, with solid sales in both Canada and the U.S. This technology may soon be applied to other cereal crops and varieties.

"The collaboration between the Saskatchewan Wheat Pool and PBI was crucial in applying the new technology to produce the first commercially-successful double haploid variety of wheat – McKenzie. This variety of wheat shows strong agronomic performance in early maturity and higher yields than other varieties."

Monty Kesslering
Manager, Seed Business Unit
Saskatchewan Wheat Pool

SIMS

Steacie Institute for Molecular Sciences (Ottawa and Chalk River, Ontario)

The fundamental things apply

Researcher with the SIMS Femtosecond Science Program aligns femtosecond laser optics for an ultrafast time-resolved measurement. Such studies lead to an understanding of the fundamental molecular dynamics underlying molecular scale electronics and photobiological processes such as vision andphotosynthesis.

The Steacie Institute for Molecular Sciences (SIMS) carries out long-term interdisciplinary research in selected areas of molecular science that can potentially impact key sectors of the Canadian economy. SIMS focuses on moving the frontiers of molecular scale sciences and technology out of the lab and into the marketplace.

With research partners both inside and outside NRC, SIMS helps develop innovative technologies across a wide spectrum including therapeutics, diagnostics, advanced electronics, telecommunications, precision manufacturing, optoelectronics, information sciences, and advanced materials. SIMS works with other NRC Institutes to determine how interdisciplinary science can support Canada's manufacturing, information and communications, and biotechnology sectors.

SIMS teams offer expertise in chemical synthesis, material characterization, understanding the chemistry of biological processes, predicting material properties, and using femtosecond lasers in optics and telecommunications research applications.

SIMS has established research in functional materials, molecular spectroscopy, neutron program for materials, femtosecond science, chemical biology, molecular interfaces, and theory and computation.

Researchers develop new optoelectronics processes
In collaboration with researchers from IMTI and IMS, SIMS developed new methods to process optoelectronic materials and devices. These will allow modification of photonic materials with micron precision in space and femtosecond precision in time, important technology for photonics integration.

Theoretical models aid intermetallic design
SIMS, ICPET and Toth Systems collaborated to develop a theoretical model to predict the structure and properties of intermetallic materials. This could lead to the rational design of functional materials for aerospace and communications industries, and bring new software to market.

Other 1999-2000 innovation highlights

- As partners in innovation, SIMS and GeneFocus set up a new company, Canadian Biochip Fabrication Facility Inc., that expects to establish frontier technologies in the protein biochip-array market
- The development of ultra-high vacuum scanning – tunnelling microscopy to manipulate atoms and molecules on silicon surfaces – is laying the foundation for next-generation molecular electronic devices.

"Our company developed a plant extraction process generating a product with different characteristics. We find NRC's Steacie Institute for Molecular Sciences a perfect complement to our corporate and research needs. The expertise and professionalism of this group is unique; they developed original tests and strategies to rationalize subtle scientific problems. Our company takes enormous advantage of SIMS' personalized work. We are not only acquiring a better understanding of the biological mechanisms, but the SIMS researchers are taking the time to discuss new alternatives we can apply to our products in the future. The scientific reports NRC writes help validate our company's technologies, which in turn assist us in obtaining important funding."

Marc Purcell, PhD
President
Pure Cell Technologies

NRC Innovation Centre (Vancouver, British Columbia)

Advancing innovation in manufacturing

NRC's Innovation Centre in Vancouver, British Columbia was established to help companies compete more effectively by innovating and applying advanced manufacturing technologies.

The Centre directly supports the manufacturing industry, by developing long-term strategic research competencies relevant to the needs of this industry, with particular emphasis on integration with other players in the British Columbia innovation community. The Centre also provides an important link to NRC Institutes and Programs across Canada.

The Innovation Centre aligns NRC with B.C.'s specific innovation needs. The Centre is a meeting place for regional innovation, offering multi-disciplinary research programs and housing the Fuel Cells Technology Centre. It is a focal point for the Industrial Research Assistance Program (IRAP) in B.C. and home to a new NRC Information Centre.

The Centre undertakes research in sensors, control and surface technologies, as well as manufacturing integration. It collaborates with manufacturing and processing sectors on projects related to wood products, value-added energy resources, process equipment and plant machinery and other areas. The Centre, which is the heart of NRC's recently announced National Fuel Cells Research and Innovation initiative, provides the valuable research infrastructure for this promising field.

Automated Intelligent Diagnostics
Utilizing advanced image processing and optics, Innovation Centre staff developed an intelligent debris analyzer for machine health monitoring which Tektrend has assimilated for commercialization.

Control system handles change on the fly
Innovation Centre staff successfully developed an adaptive, self-tuning, predictive control system that can handle processes and machines with changing dynamics, such as pneumatic and fuel cell systems, and vehicles to ensure better performance.

Development of fuel cells has progressed beyond transportation to new applications for stationary power sources for homes and industry.

"Thanks to the work of the IDA [Intelligent Debris Analyzer] project team from NRC's Innovation Centre, Tektrend gained a new range of technical capabilities which promise to help our company step to the forefront of the global non-destructive inspection market. In turn, this potential growth and international prestige bodes well for Canada as a technologically-innovative nation, and lends credibility to our efforts for international recognition as a leader in non-destructive inspection research and development."

Ahmad Chahbaz
Vice President, R&D
Tektrend

"The work done... at NRC combined with the efforts of Optimil Machinery employees gave us a new understanding of how well pneumatic control of heavy mass can perform. Air just does not behave itself like hydraulics do. The new GPC algorithm that the team developed shows real potential in this area. The performance is far beyond what we could ever achieve with traditional control systems.

We now have a number of units running in sawmill machinery applications, but there are many applications outside our industry and we are tapping into these too... The GPC algorithm will distinguish our product from our competitors."

John Chapman
Technical Director
Optimil Machinery Inc.

NRC TECHNOLOGY CENTRES

CSTT – Centre for Surface Transportation Technology (Ottawa, Ontario and Vancouver, British Columbia)

CSTT operates as a cost-recovery NRC Technology Centre, offering clients its unique expertise, and facilities to improve the productivity, competitiveness, reliability and safety of rail and road transportation equipment and systems. CSTT's expertise includes vehicular engineering research and development, computer modelling and analysis, field testing, climatic simulation and vehicle performance.

CSTT methodologies have improved Canadian safety standards for tank containers carrying dangerous goods. The Centre is developing improvements to introduce North American freight rail technology and equipment in other parts of the world and designing performance-evaluation methodology to improve such things as aircraft de-icing fluids.

CHC – Canadian Hydraulics Centre (Ottawa, Ontario)

CHC is Canada's largest hydraulics and coastal engineering laboratory. It operates on a cost-recovery basis, providing physical and numerical modelling and analysis services in the general field of hydraulics to Canadian and international engineering communities. CHC specializes in coastal engineering, environmental hydraulics and cold-regions technology. CHC facilities available to industry include three large wave basins, two wave flumes, a coldroom and an ice basin which are used for physical model studies of: breakwaters; harbours; ship moorings; beach and shoreline protection; near and offshore fixed and floating structures; scour and depression of sediments; ice forces on structures; and river and estuary hydraulics.

CHC also develops and applies advanced numerical models of: wave propagation (motion and forces of both intact and broken ice covers interacting with structures); coast environmental management; water resources; rivers and watersheds; sediment transport; pollutants; oil and chemical spill fate; water quality; environmental production; and decision support systems.

TTC – Thermal Technology Centre (Ottawa, Ontario)

TTC engineers, researchers and technologies offer R&D services related to thermal engineering systems and advanced process heat transfer equipment to clients working in fields such as: commercial refrigeration, air-conditioning, and heat pump and process heat transfer equipment manufacturing. Working on a cost recovery basis, TTC combines its specialized technical competencies and experience with state-of-the-art test facilities, in collaboration with industry, and government departments and agencies that are particularly focused on energy and the environment.

NRC'S GOVERNING COUNCIL

(as of 31 March, 2000)

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